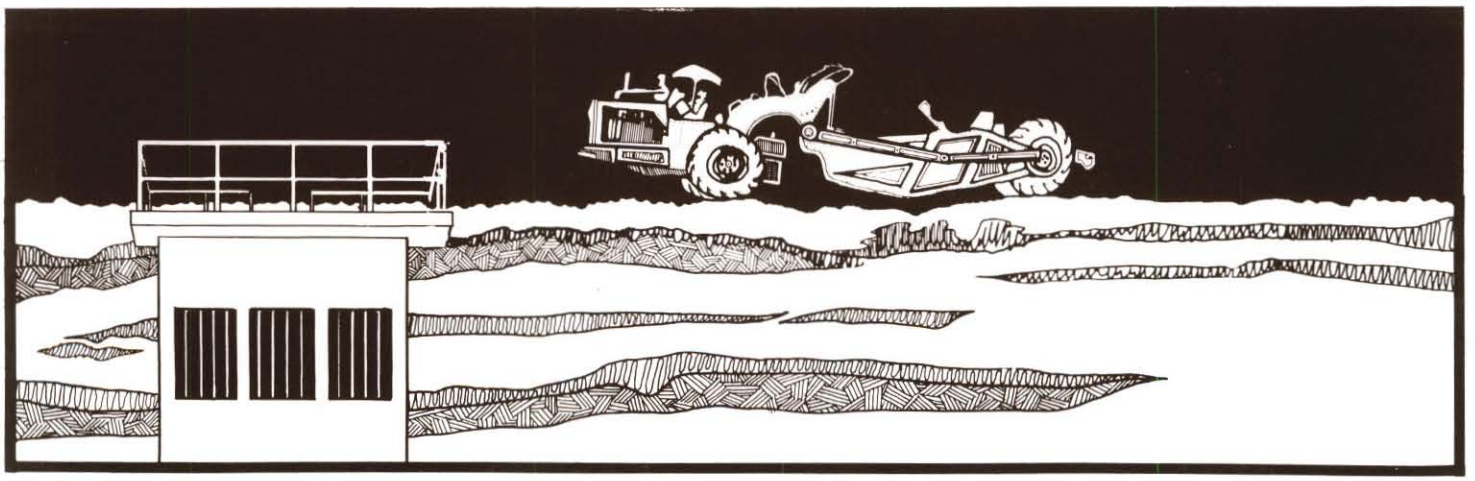
POLICY ISSUE STUDY
ON

SUPPLEMENTAL WATER SUPPLIES

State Water Planning and Review Process
Nebraska Natural Resources Commission

JANUARY 1984



POLICY ISSUE STUDY
ON
SUPPLEMENTAL WATER SUPPLIES

STATE WATER PLANNING AND REVIEW PROCESS

SUPPLEMENTAL WATER SUPPLIES REPORT

REPORT
OF THE
NATURAL RESOURCES COMMISSION
TO
GOVERNOR ROBERT KERREY
AND
THE MEMBERS OF THE NEBRASKA LEGISLATURE

JANUARY 1984

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PROGRAMS:

SOIL & WATER CONSERVATION
WATERSHED PROTECTION
COMPREHENSIVE PLANNING
FLOOD PLAIN MANAGEMENT
DATA BANK
WATER CONSERVATION FUND
DEVELOPMENT FUND

STATE OF NEBRASKA

NATURAL RESOURCES COMMISSION

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September 1, 1983

The Honorable Robert Kerrey
Governor, State of Nebraska
State Capitol
Lincoln, Nebraska 68509

Members of the Nebraska Legislature
Eighty-Eighth Nebraska Legislature
First Session
State Capitol
Lincoln, Nebraska 68509

Dear Governor Kerrey and Members of the Legislature:

This report entitled "Policy Issue Study on Supplemental Water Supplies" has been reviewed and approved by the Natural Resources Commission. It is the final report of one of a series of Commission studies of water policy issues.

Thirty policy alternatives which could facilitate the development of supplemental water supplies are presented in the report. The report also analyzes the impacts of those alternatives. The Commission's recommendations on the alternatives are also provided and can be found on the blue pages immediately following the Table of Contents.

It is the hope of the Natural Resources Commission that this report will be helpful in making policy decisions and, if necessary, statutory changes. The Natural Resources Commission is prepared to answer any further questions you may have.

Sincerely,

Clinton VonSeggern

Clinton VonSeggern
Chairman, Natural Resources Commission

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Foreword

This is one of a series of water policy studies that are part of the State Water Planning and Review Process. It addresses alternative policies for development of supplemental water supplies in Nebraska and is being forwarded to the Governor and Legislature for action as deemed appropriate.

In most respects this report is the same as the final task force report prepared by the Conservation and Survey Division of the University of Nebraska with the aid of an interagency task force. The Natural Resources Commission has added a transmittal letter, this foreword, and a small section on the public hearing on this report. In addition, some modifications were made in portions of the report, especially the introduction, summary, and Chapter 1, and the addition of *Alternative #27*. Five Alternatives were also deleted from the original Task Force report because they were adopted into law after that report was published. Their contents are now discussed as part of current policy. However, the major change is the addition of the policy recommendations contained in the following section of this report.

The interagency task force which helped the Conservation and Survey Division develop the data and alternatives used in the final task force report included:

Vince Dreeszen . . . . . Conservation and Survey Division, UNL
Jon Atkinson . . . . . Department of Environmental Control
Lee Becker . . . . . Department of Water Resources
Bob Burns . . . . . Water Resources Center, UNL
Karen Langland . . . . . Policy Research Office
Cliff Summers . . . . . Department of Health
Jerry Wallin . . . . . Natural Resources Commission
Gerald Chaffin . . . . . Game and Parks Commission

The Conservation and Survey Division served as lead agency for the Task Force with Bob Kuzelka serving as Task Force Coordinator. The Conservation and Survey Division was responsible for leading the work of the task force and writing the final task force report.

Non-task force members who contributed greatly to the report include Marilyn Ginsberg, Conservation and Survey Division; Mark Nelson, Department of Water Resources; Mike Jess, Department of Water Resources; Charles Deknatel, Department of Community and Regional Planning, UNL; Ray Supalla, Department of Agricultural Economics, UNL; Dave Aiken, Department of Agricultural Economics, UNL; and Tom Cech, Water Resources Center, UNL.

Following initial consideration of the task force report the Commission distributed a draft report for public review on March 28, 1983. The public comment period concluded June 17th. Public meetings on the report were held on May 31 in Ogallala and June 1 in Grand Island. A public hearing was held in Norfolk on June 2. Summaries of the hearing and meetings are available as a special section at the back of this report.

The Public Advisory Board devoted considerable time to discussion of the task force report and provided the Commission with a number of recommendations. In addition, written comments were received from members of the public representing either themselves, or particular organizations. All such comments are on file at the office of the Commission and are available for review.

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Comments and Recommendations of the Natural Resources Commission

The Commission believes that development of supplemental water supplies is an important investment in Nebraska's future. The funding and construction of economically feasible water supply projects represents one of two methods by which the state may achieve a more thorough use of one of our most valuable resources. The other method is water use efficiency, which will be addressed in an upcoming policy issue study.

In general the Commission recognizes a higher level of state funding as the major element in any state effort to expedite the development of supplemental water supply projects. A number of alternative funding mechanisms are presented in this report. Although we prefer some methods to others, we believe the question of what funding method to use is secondary to the objective of actually providing increased funding. Many of our other recommendations would have diminished impact if additional monies are not provided.

Because we believe water project funding is a key issue we are dividing these comments and recommendations into two sections. The first section presents a specific project funding package. This represents our best judgement of the manner in which the state should approach its future water project funding needs. We strongly endorse adoption of this package. The second section presents our comments and recommendations on each alternative contained in the *Policy Issue Study on Supplemental Water Supplies.*

SECTION 1 - THE COMMISSION'S RECOMMENDED WATER PROJECT FUNDING PACKAGE

From its experience as the official state water planning agency and the administering agency for the Resources Development Fund, the Commission has arrived at the following conclusions about the financing of water projects in the state:

1) Greater state financial input into water resources project development is essential, but the magnitude of the need is not known because: (a) the status of federal cost-sharing (for both planning and construction) is unresolved; and (b) the number and cost of feasible Nebraska projects is not known.
2) Appropriation of large sums now for project development cannot reasonably be expected when the needs can't be quantified.
3) Sponsors of potential projects are not willing to commit large expenditures to project planning when there is no assurance that funds will be available for construction when planning is done and feasibility determined. This is a problem on non-federal projects and may be a problem for federal projects if cost-sharing for federal projects if cost-sharing for federal planning becomes common.

Developed in response to these conclusions, our suggested funding program has several major components, including: an increased funding level for the Resources Development Fund and a sinking fund for aiding local projects, funding and implementation of a state project planning and design program, modification and then adoption of LB 545 (88th Legislature), and authorizing the issuance or guarantee of general obligation bonds for water projects. Our specific funding recommendations are as follows:

COMPONENT #1

Fund and implement the project planning and design component of the state water planning and review process. The $62,200 requested for this activity for the FY 85 budget should be considered a minimum. Priority will be placed upon scoping and designing this component in FY 84 even though no funds were specifically apppropriated therefore. Dollar needs for fiscal years subsequent to FY 85 will have to be determined after the component is designed. This component might need to include provision of cash to satisfy federal cost-sharing requirements for planning.

COMPONENT #2

Immediately increase the level of appropriation to the Resources Development Fund (total appropriation of 10 million per year suggested) and obtain

clear legislative and gubernatorial endorsement of a sinking fund concept. Legislation for the sinking fund should contain a provision that interest earned will be returned to the fund. Not less than 5 million of the 10 million annual appropriation should be committed to the sinking fund. For a project to be eligible for funds in the sinking fund, it should be large enough to require at least a five million dollar state commitment.

This new approach would allow us to continue to meet the small project funding needs and also to become prepared to meet intermediate monetary needs including, hopefully, some required non-federal cost-shares. The current Resources Development Fund should serve as the vehicle for initial administration of the new funds, but it is recognized that some changes in eligibility criteria and operation of that fund eventually could be needed. Also, provisions should be made to hire additional staff to administer the additional appropriations. The Resources Development Fund has had money provided for only one staff person, with other work donated by participating agencies. It is unlikely that such an approach would work on an expanded fund where even more donation of time by several agencies would be required.

COMPONENT #3

Modify LB 545 so that the revenue bonds authorized would be used as a source of funds for Commission acquisition of state interests in resources projects that will return revenue to the state; e.g., M & I water, irrigation, etc. In November, 1982, the voters of the state approved an amendment to the Nebraska Constitution authorizing the issuance of state revenue bonds for water retention and impoundment structures. Since the bonds authorized are of the revenue variety, they are to be repaid by state revenues derived from use of the structures rather than from general taxation. The stated purpose of LB 545, a bill introduced in the 1983 session of the Legislature, is to implement the constitutional amendment approved by the voters in November of 1982. However, the Commission believes that LB 545 should be rewritten so that revenue bonds may be utilized to compliment the existing Resources Development Fund. The legislation governing that fund presently authorizes Commission acquisition of state interests in resources projects with vendible water supplies. To date, no opportunities for using such authority have been presented. While such opportunities could be expected to also be rather limited in the future, they will exist on occasion and the ability to take advantage of them when they do should be granted. State revenue bonds would appear to be the most logical way to proceed in this regard.

Beyond the Commission acquisition authority discussed above, little opportunity for use of state revenue bonds presently exists for water project construction. Natural Resources Districts and many other local resources related political subdivisions have revenue bonding authorities of their own and little or no need for state revenue bonds. The authority granted by the Constitutional amendment could not be **fully** implemented unless a **state agency** were given the necessary authorities to sponsor and construct water projects. The Commission does not believe such an extension of state agency authority is presently needed; however, it may deserve future consideration.

COMPONENT #4

Option #1: Propose an amendment to the Nebraska Constitution to authorize the issuance of general obligation bonds for:

(a) **Water retention and impoundment structures** (as revenue bonds are presently authorized for);

(b) **All eligible Resources Development Fund projects; OR**

(c) **All water related projects, to include waste treatment facilities and municipal water distribution facilities.**

In contrast with the revenue bonds discussed as part of Component #3, the full faith and credit of the issuing governmental entity is pledged to repayment of general obligation bonds and they are normally repaid from general tax revenues. They are used to generate large amounts of money when needed for capitol investments, with repayment occurring over the term of the bonds. General obligation bonds could be utilized to raise funds for specific large practices or if desired by the Legislature, for general funding of the Resources Development Fund or other water resources project financing mechanisms. Legislative approval of each general obligation bond issue would be required. If the broadest form of authority for such bonds were granted (type (c)), the proceeds of the bonds could be administered through the Resources Development Fund and the Wastewater Program administered by the Department of Environmental Control.

Option #2: Propose an amendment to the Nebraska Constitution to authorize state guarantee of local general obligation bonds for project types (a), (b), or (c) and modify the Resources Development Fund so that state grants and loans are used to retire the local bond issues.

Both options in this component are capable of generating large project dollars when needed; i.e. when local revenues and the sinking fund included in Component #1 are not adequate. The Commission has a

slight preference for Option #1 because it is simpler to implement. However, either option is most acceptable.

The Commission believes that the above water project funding package provides for an affordable increase in the state's financial commitment to resource development. We also believe that it would result in initiation of a systematic procedure for identifying additional projects worthy of funding. Finally, it would create a mechanism adequate to generate large amounts of dollars when needed, such as for upfront financing for large federal projects, or for major projects constructed without federal funds. We strongly support implementation of all components as outlined.

SECTION 2 - COMMENTS AND RECOMMENDATIONS ON POLICY ALTERNATIVES

In the following paragraphs are our comments and recommendations on each legislative and management alternative contained in the report. At this point it should be noted that legislative action in the 1983 legislative session resulted in deletion of several alternatives contained in our original task force report. Adoption of LB 198 resulted in three alternatives becoming a part of present policy. These were: "Clearly authorize the appropriation of surface water to recharge groundwater reservoirs," "Legally authorize water suppliers to modify surface water appropriations without loss of priority (a) to reflect the reduction of direct surface water use in favor of recharged groundwater, and (b) to reflect that surface water is being stored underground for use," and "Legally authorize water suppliers to store water underground and to levy a fee for withdrawing water stored underground." The Commission strongly agreed with the adoption of LB 198.

An alternative to "allow districts to determine the maximum size of drainage areas for a water impoundment structure" being built in part with money from the Water Conservation Fund became a part of current policy with the adoption of LB 236. Therefore, it was also deleted. An alternative to "authorize water users to exchange water from different sources subject to the protection of existing surface appropriation" was deleted because the Commission felt that that topic was adequately addressed elsewhere in the report.

Our comments and recommendations on the alternatives now contained in the report are as follows:

ALTERNATIVE #1 (formerly #4): Authorize water suppliers to vary surface water and groundwater use fees to achieve a balanced use of each.

The Commission recommends adoption of *Alternative #1* with the stipulation that NRDs and other water suppliers be able to use either fees or regulation. We do not choose to specify the details of this recommendation due to the complexity of the law. However, we do believe that such fees and regulations would be a valuable tool to help manage water supply. As noted earlier, the Commission endorses the concept of integrated management as embodied in LB 198 in the 1983 session of the Unicameral.

ALTERNATIVE #2 (formerly #6): Authorize groundwater transfer for agricultural purposes to include irrigation, recharge, and surface and underground storage.

The Commission recommends that this alternative be adopted with certain provisions to protect the area of groundwater origin. We would first define overlying land as contiguous land under the same ownership within one mile of the point of groundwater withdrawal. We then recommend that all transfers to overlying land be allowed. We also recommend that transfers to non-overlying land be allowed on a permit basis. Such permits would be issued by the Department of Water Resources if it was determined by specific criteria that the transfer would result in no substantial adverse impacts to the general area of groundwater origin.

One impact of this alternative which is not discussed elsewhere in this report is its impact on Nebraska's ability to control interstate transfers of Nebraska groundwater. Two recent cases in this area make it clear that discrimination of out-of-state residents in favor of in-state residents is extremely difficult to justify if not absolutely prohibited. Thus, if a groundwater transfer policy is adopted as recommended, it will almost certainly have to be applied across state lines as well as within the state.

ALTERNATIVE #3 (formerly #7): Declare that groundwater may be used to supplement streamflow needs.

The Commission does not recommend adoption of this alternative. We continue to believe our recommendations on the *Policy Issue Study on Instream Flows* are the best method of addressing this issue. This would be a very expensive option to implement.

ALTERNATIVE #4 (formerly #8): Remove the preference for junior direct flow irrigation appropriators over senior storage appropriators.

The Commission does not recommend adoption of this alternative. If the alternative were adopted it would mean that storage could occur at a time when there were downstream appropriators who could use the water. Later off-season precipitation and base flows could fill the storage facility to the point that the water would be released and flow down the stream unused. We believe this would be a waste of a valuable resource.

Because the present law allows a preference only for junior direct flow irrigation appropriators we do not believe there is a danger of storage rights being threatened by year-round uses such as recharge or electric power. Therefore, we recommend that the statute remain in its current form.

ALTERNATIVE #5 (formerly #9): Develop more specific guidelines as to what is necessary to extend as application for water for a supplemental project that not been completed.

The Commission does not recommend adoption of this alternative. We believe that the current statutes maintain a suitable balance between the need of project sponsors to have their water rights protected during periods of reasonable delays and the need of the state to see that water is not wasted.

ALTERNATIVE #6 (formerly #10): Increase annual appropriation to the resources development fund.

The Commission strongly recommends adoption of this alternative as part of the overall funding package. Construction of economically feasible water storage projects should be a major state funding priority. A higher level of funding would encourage larger projects and more applications. It would also give local sponsors more certainty about state funding commitment to their projects.

ALTERNATIVE #7(formerly #11): Designate an add-on (increase) to an existing state tax such as sales or income tax to be used for supplemental water projects.

The Commission believes revenues must be raised for water projects, and we would support this alternative in preference to no increase in funding. However, we do not believe this is the best method of generating additional funds.

ALTERNATIVE #8 (formerly #12): Levy a special tax on commodities such as cigarettes or liquor to be used for supplemental water projects.

We do not believe that this alternative is the best method of generating additional funds. We would support this alternative in preference to no increase in funding. However, we do not believe that special taxes on commodities are the fairest method of generating revenue.

ALTERNATIVE #9 (formerly #13): Specify that a percent of the severance (oil and gas) tax fund be used for supplemental water projects. (Amendment to Neb. Rev. Stat. §76-1801)

The severance tax on gas and oil is currently used for education. If we were to begin using this fund for water projects an alternative source of education funds would need to be found. We don't believe that cutting our funds to educational activities is the way to finance water projects. We would find the opposition such a move would generate to be understandable. While we support funding projects, we suggest that another method be found.

ALTERNATIVE #10 (formerly #14): Implementation of the amendment to article XIII, Section I of the constitution of Nebraska by passing legislation which would allow revenue bonds to be issued for construction of water retention and impoundment structures.

The Commission strongly recommends that this alternative be adopted. We supported adoption of the constitutional amendment which made this legislation possible. In passing that amendment the people of Nebraska made their commitment to water resources development clear. We believe it is now time to take the final step by passing legislation which allows revenue bonds to be issued. Such a final step can be taken by passing LB 545 in the modified form previously suggested in our funding package.

ALTERNATIVE #11 (formerly #15): Allow the State to issue general obligation bonds with or without a referendum for development projects. (Amendment to constitution of Nebraska, Article XIII, SEC. 1.)

The Commission strongly supports adoption of this alternative. It is an integral part of the funding package presented in the first section of these recommendations. As discussed in that funding package, an acceptable variation of this alternative would be state guarantee of local general obligation bonds.

ALTERNATIVE #12 (formerly #16): Allow the State to institute water-use fees to be used as revenue to pay for supplemental water projects.

Although the Commission does not believe this should be the sole method of obtaining funds for water projects, we do support adoption of this alternative. We feel that having water users pay a higher share of taxes used for water development is a fair method of raising revenues. We also believe it would help lend credibility to the remainder of a legislative package for water development.

ALTERNATIVE #13 (formerly #17): Allow exceptions to the local Option Tax Control Act for increases in expenditures by local governments for supplemental water developments. (Amendment to Neb. Rev. Stat. §77-3401 Et. Seq.)

The Commission does not recommend adoption of this alternative. We believe that this type of act must be applied equitably among all political subdivisions or not at all. Since the Act has a sunset clause as of December 31, 1984, changes in the Act might not substantially impact funding in any case.

ALTERNATIVE #14 (formerly #18): Allow tax-increment financing by local governments for the purposes of funding the development of supplemental water projects. (Amendment to the Constitution of Nebraska, Article VIII, Section 12)

The Commission recommends adoption of this alternative. Tax increment financing has been used to construct other revenue producing facilities such as Lincoln's Cornhusker Square Project. We believe that extension of such a concept to water supply projects is sound. Because increased tax revenues from the project are actually used to finance the project we believe that this is an equitable method of financing construction.

ALTERNATIVE #15 (formerly #19): Allow a general land tax on the capital gain (appreciation in the value of land) which can be attributed to an irrigation project. Such a tax would require a constitutional amendment and subsequent enabling legislation.

The Commission recommends that this alternative not be adopted. An attempt to "force" landowners to become part of a project through taxes would result in a great deal of opposition to the project's ever being built. We do not believe that this type of government pressure is desirable.

ALTERNATIVE #16 (formerly #20): Authorize local governments to allow water suppliers to charge a water-use fee as a method to produce revenue for providing supplemental water.

We interpret this alternative to be a means of implementing a locally imposed water severance tax and the Commission recommends its adoption. If the general public is being asked to support water supply projects through our general tax structure, we believe it is appropriate to ask water users in local areas to bear an extra measure of water project costs.

ALTERNATIVE #17 (formerly #21): Authorize natural resources districts to levy a specific rate which could only be used by the district for planning and capital construction on supplemental water projects. (Amendment to Neb. Rev. Stat. §2-3201 et seq.)

The Commission recommends that this alternative be adopted. This would give local areas additional project construction capability. It would allow districts to more effectively utilize available state funding. It would also help place some major responsibilities for water supply projects in the hands of locally elected officials.

ALTERNATIVE #18 (formerly #22): Authorize natural resources districts with voter approval to issue general obligation bonds for capital construction costs and administrative and interest costs relating to supplemental projects. Such legislation would provide for tax authorization to secure adequate bond repayment revenue. (Amendment to Neb. Rev. Stat. §2-3201 et seq.)

The Commission recommends that this alternative be adopted. Due to voter approval requirements use of the bonds would ensure local support for a project before it was built. These types of bonds are issued for certain other types of public projects. We see no reason why they should not be used for water supply projects as well.

ALTERNATIVE #19 (formerly #23): For purposes of the Resources Development Fund, establish economic feasibility so that a supplemental water project would not have to meet the criteria that its primary costs do not exceed its primary and tangible benefits. For instance, secondary benefits and costs could be considered as well. This change could be made by the Natural Resources Commission and the Development Fund Advisory Board or it could be mandated by the Nebraska legislature. (Amendment to Neb. Rev. Stat. §2-3263 et. seq.)

The Commission does not support this alternative. The present policy of not using a discount rate for Development Fund Projects provides considerable advantage in calculating economic feasibility of projects using only primary benefits. Furthermore, a good analysis of secondary benefits and costs would be costly and time-consuming from an administrative standpoint.

ALTERNATIVE #20 (formerly #24): Allow Resources Development Fund grants to be used for supplemental water projects that reduce revenue. (Amendment to Neb. Rev. Stat. §2-3266)

The Commission does not recommend adoption of this alternative. We believe that revenue producing projects should repay their costs to the degree possible. The Development Fund already makes low cost loans available to such projects.

ALTERNATIVE #21 (formerly #25): Projects that include the development of large-size storage facilities would be given preference in the Resources Development Fund.

There are currently no Development Fund criteria working against large-scale projects. In fact, present priority criteria gives a slight advantage to large projects. The Commission will ask the Development Fund Advisory Board to consider whether such a criteria should be given more weight.

ALTERNATIVE #22 (formerly #25): Projects which can physically include integrated management as a purpose would be given preference in the Resources Development Fund. This would require developing a clear method of assessing benefits from groundwater recharge and other aspects of integrated management.

The Commission believes that development of a clear method of assessing benefits from groundwater recharge and other aspects of integrated management would be a major help in assessing projects. We certainly feel that those benefits should be considered when assessing a project. However, we will ask our Development Fund Advisory Board to consider whether a preference should be given to projects incorporating integrated management.

ALTERNATIVE #23 (formerly #27): In administering the Nebraska Soil and Water Conservation Fund, the Natural Resources Commission could require that Natural Resources Districts place a priority of projects and practices to be funded which would offset the need for supplemental water supply by improving groundwater recharge potential. This change could also be mandated by the Nebraska legislature. (Amendment to Neb. Rev. Stat. §2-1579)

The Commission supports enactment of this alternative. Conservation of water must be an extremely important element of any state effort to manage our water resources. Our upcoming Policy Issue Study on Water Use Efficiency will examine water use practices that conserve water more closely.

ALTERNATIVE #24 (formerly #29): Direct through legislative intent that NRC implement the State Project Planning and Design portion of its legislation and provide specific appropriations to NRC for this purpose.

The Commission recommends that this alternative be adopted and we have included it as part of our funding package. This activity has not been implemented to date due to low budgetary levels and a lack of specific funding commitment or direction from the legislature. At this time we believe a program should be initiated to begin state planning and design of projects. Because of its grassroots ties to local Natural Resources Districts, we believe that the Natural Resources Commission is the logical agency to initiate such a program.

ALTERNATIVE #25 (formerly #30): Strengthen the policy of the state engineer (Director, Nebraska Department of Roads) to construct road structures which can be incorporated into the design of water impoundment structures.

The Commission does not recommend adoption of this alternative. The state currently has a law requiring the Department of Roads and County Boards to consult with the Natural Resources District before construction of a bridge or culvert. The Department of Roads has indicated that it complies with this statute and that it only has a very small number of new road miles scheduled for construction. We have not been able to determine whether all county boards comply with this consultation requirement. However, we believe the present consultation requirement to be appropriate and urge the Department of Roads, the county boards, and natural resources districts to strictly comply with it and to utilize it as intended — as a meaningful mechanism to take advantage of multi-purpose opportunities when they are presented.

ALTERNATIVE #26 (formerly #31): Authorize local governments to collect payments in lieu of taxes for land which is used by the construction of supplemental water projects. The amount of these payments in lieu of taxes could be adjusted in accordance with property assessments as required by the Nebraska Department of Revenue. This would require an Amendment to Neb. Rev. Stat. 70-651.01 for public power districts and a constitutional amendment and new legislation for other water project development entities.

The Commission recommends a limited adoption of this alternative. We advocate payment of in lieu of taxes to offset a net tax loss due to project development. However, we only advocate that payment so long as the tax loss to the governmental unit has not been offset by local tax revenues generated by increased economic activity due to the project. This would help governmental units which had land removed from tax roles due to construction but which received few immediate project benefits such as project irrigation land, economic activity from recreation, or flood control. While we recognize that this would add to project costs in some cases, we believe that local governments should not be unfairly burdened.

ALTERNATIVE #27 (new alternative): Amend Section 37-435(3) and other Sections of the non-game and Endangered Species Act so that the State Act includes an exemption process and is otherwise consistent with the Federal Act.

The Commission recommends adoption of this alternative. While we recognize protection of endangered species as a priority, we do not believe it should always be an absolute priority. This amendment would allow the state to balance the benefits of a project against unavoidable costs to endangered species. The amendment would also bring the state into more nearly complete conformance with the federal law.

However, we do note that for most projects the federal endangered species law is also likely to apply. This means that in most cases if Nebraska does grant an exemption, a federal exemption will also need to be obtained. The exceptions would be cases where a threatened or endangered species is designated only by the state, or where no federal funding or permits are involved. This change in state law would apply directly in those cases.

ALTERNATIVE #28 (formerly #32): Direct some entity to develop a plan to obtain and use supplemental water from the Missouri River.

The Commission supports adoption of this alternative. We recognize that large scale transfer schemes studied to date are financially infeasible at current crop prices. However, we believe that smaller scale irrigation transfers and energy related transfers both hold immediate promise. The electrical peaking facilities of the Gregory project and South Dakota's sale of water for the coal slurry pipeline are examples of potential energy uses. We also believe that if crop prices rise and interest rates drop the larger scale transfers could hold promise. Therefore, we believe Nebraska should more carefully examine its prospects for use of Missouri River water. This might be accomplished in connection with *Alternative #24* which implements the state project planning and design portion of the State Water Planning and Review Process.

ALTERNATIVE #29 (formerly #33): Institute and fund a type of public works program that would relieve unemployment and develop supplemental water supply projects.

The Commission does not recommend adoption of this alternative. We acknowledge the invaluable role that the federal public works programs begun in the 1930's played in water project development in Nebraska. However, we do not believe that current conditions warrant those types of programs.

ALTERNATIVE #30 (formerly #34): Establish a Water Development Advocacy Agency in Nebraska. This would require the Nebraska Legislature to create such an agency or significantly "overhaul" an existing agency.

The Commission recommends that *Alternative #24* be implemented in place of this alternative. That alternative provides for implementation of the Commission's "State Project Planning and Design Activity." We do not believe that a new or substantially overhauled agency is needed. We also believe that the Commission's ties to the local level of government make it the logical agency in which to house a project planning effort.

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SUMMARY

INTRODUCTION

The *Supplemental Water Supplies* policy issue study is one of a series of water policy studies that are part of the Nebraska State Water Planning and Review Process. The product of this study is a report which provides information to decision makers on methods of facilitating the development of supplemental water supplies in Nebraska and the impacts of those methods. This report examines supplemental water, its uses, its sources of supply and constraints to its development. The report concludes with a review of present policies for development of supplemental water and an examination and impact analysis of thirty alternatives that might facilitate its development.

SUPPLEMENTAL WATER

Supplemental water is additional water provided to supply that which is lacking, i.e., needed or desired. It is considered to be water which is made available for use within a specific area by moving it from one area to another and/or storing it for use at a later time. Supplemental water can be provided by constructing surface-water reservoirs, by adding to groundwater storage and by importing groundwater or surface water from another area. In this study, natural streamflow that is diverted to riparian land and groundwater that is used within one mile of the point of withdrawal are not considered supplemental water.

Certain sources and methods for supplementing water supplies were considered in the study but not included in detail in this report. These include using the soil profile as a source and storage site, reducing evapotranspiration, modifying the weather and reducing losses from surface water.

Surface water and groundwater are traditional sources of supply for developing supplemental water. This study, in addition to considering them as independent sources, also considered the integrated, or conjunctive use of water from these two sources. Such integrated management may result in the most efficient use of Nebraska's water. Supplemental water which is made available through integrated management is suggested to be a new class of water.

The opportunities for use of supplemental water now and in the future in Nebraska are many and varied. The greatest demand undoubtedly will continue to be for its use in irrigation. The priority of use for supplemental water will continue to be set by needs, desires and economics. An important part of economic considerations will be the willingness or ability of the beneficiaries to pay an increased portion of the project cost. The public will make the final decision through the political process.

SUPPLEMENTAL WATER USE

The variations in the precipitation pattern in the state create an opportunity for use of supplemental water. The low annual rainfall in western Nebraska of 15 to 21 inches makes irrigation necessary to maintain most agricultural production. The departure in annual rainfall from the average (up to 7.6 inches), plus the inconsistent weekly and monthly pattern of rainfall in any year create an opportunity for improving production by irrigation in the entire state. The inadequacy of direct sources of water for irrigation in many parts of the state create a need for supplemental water supplies.

The declining water levels in some portions of the state create a second major opportunity for use of supplemental water. Frequently these have occurred in areas where direct application of groundwater is a major means for meeting irrigation requirements. The result is a need for improved management and/or introduction of water from outside sources.

The soil types and slopes in most areas of Nebraska are very suitable for irrigation development. Because many highly suitable lands are located away from available and sufficient surface water or groundwater, they present another opportunity for the use of supplemental water should other constraints such as economic factors be overcome.

There are other uses, in addition to irrigation, that present opportunities for the use of supplemental water in Nebraska. They include municipal uses, livestock and rural domestic uses, uses which arise from electric power generation, industrial uses and fish, wildlife and outdoor recreation uses.

SUPPLEMENTAL WATER SUPPLY

In Nebraska both surface water and groundwater are potential sources of supply for supplemental water. Total outflow from the state's streams averages from about 5 million acre-feet in dry years to more than 15 million acre-feet in wet years. The fact that close to half of this flow originates in the generally lower elevation eastern third of the state and that areas with higher economic potential generally occur in upstream areas to the west presents definite economic, technologic, and environmental constraints to its use. However, some of this supply could be stored and/or diverted for use at other times and in other places. Groundwater reservoirs which are recharged by losing reaches of streams represent a unique source of surface water that has become groundwater.

Even with a projection of 200 years of maximum development of groundwater for irrigation on overlying land, there would be groundwater in portions of central and northwest Nebraska available for supplemental supplies. Additionally, the mounding of groundwater south of the Platte River in central Nebraska is another source for such supply.

In addition to a supply, most supplemental water development requires that the water be transferred over or under the ground. In Nebraska there still is limited potential for gravity transfer systems. Because much of the remaining source of supply is at the lower elevations in the eastern portion of the state, many supplemental water developments in the future will require pumping and lifts. These methods of transfer may introduce many technological, economic, and environmental constraints.

There are potential sites across the state for the storage of water on the surface. Over 200 sites which would have a normal capacity of 1,000 acre-feet or more have been studied previously by others. The facilities which might be built on these sites could not only directly supply water, but in many cases have the potential to recharge the groundwater reservoir. In some cases they could also serve such uses as flood control, power generation, or fish, wildlife and recreation.

Underground storage of water in many areas of the state represents an important potential for the future development of supplemental water systems. These areas include locations where there have been water-level declines in the groundwater reservoir and where there are layers of unsaturated materials which could contain and release water.

IMPACTS AND CONSTRAINTS

When an impact from a supplemental water development is proven, or is perceived to be a hindrance to development, then the impact is considered a constraint. Impacts and constraints can result from a variety of environmental, technological, social, legal, institutional, or economic factors.

The results of this study seem to indicate that often there are net environmental impacts which would be considered negative in the area where groundwater is withdrawn for use as a supplemental water supply. By contrast, the net environmental impacts would usually be positive in areas where the groundwater reservoir might be used for storage purposes. Both surface storage and transfer of water could face environmental constraints or have positive environmental impacts, depending on the site and management of the development. The debate over which effect might occur is most often a result of the evaluator's perspective and of a lack of environmental data for a specific instance or site.

Most technological factors which are obstacles to the development of supplemental water supply systems can be overcome. However, overcoming the technological obstacles may be very costly — beyond the benefits of the development.

Social constraints to supplemental water development are many, varied and closely dependent on the type of development and its specific location(s). The attitudes of people become the major social constraint. Their attitude may be formed in reaction to social impacts on land use, population or the local economy. These attitudes also may be in relation to how tax dollars are spent and who receives benefits. Or, their attitudes may be related to traditions and mores. In any event, the expression of peoples' attitudes in a democratic society through social pressures, the political process and the legal system can present a constraint that cannot be ignored in developing supplemental water supplies.

The two aspects of Nebraska surface and groundwater law most constraining supplemental water-supply development are: (1) the preference for junior natural-flow appropriators over senior storage appropriators during the irrigation season, and (2) the absence of clear agricultural groundwater-transfer authorities.

The major federal institutional constraints to supplemental water project development are environmental and financial. One major federal environment constraint is that many proposed projects could cause environmental problems and thus may be politically challenged because of material contained in the environmental impact statement or legally challenged because some parties may not believe the statement is adequate. Another instance where institutional protection of the environment may constrain project development in Nebraska is the Platte Whooping Crane Critical Habitat designation by the Federal Government. A major state environmental constraint is the requirement that state actions not jeopardize the continued existence of threatened or endangered species or their critical habitat. The major financial constraints seem to be (1) the availability of federal water resources

development funds and (2) the conditioning of that funding on the availability of significant state and local funding. While the latter factor will increase the cost to Nebraskans of federal supplemental water projects, the possible changes in federal financing policies may not be necessarily constraining. However, the existing federal financial feasibility criteria have served as a constraint. Any required increase in state and local financing could come either from higher water-use charges, higher local and/or state taxes, or some combination thereof. These changes may prove to be financially, and therefore politically, constraining.

There are two economic factors which potentially constrain water development: (1) the identification of projects where the investment generates net benefits at least equal to what the funds would have generated elsewhere, and (2) the availability of funds to finance economically efficient projects. With respect to economic efficiency, the analysis of selected projects reveals that there exists at least some economically efficient development alternatives once interest rates decrease to more conventional levels. In view of the large expenditures required, it seems likely that the most limiting economic constraint will consist of the difficulties in financing economically efficient projects.

The following section of this summary examines 30 alternative legislative and management actions related to supplemental water supply. Although the impacts of these alternative actions are not contained in the Summary, they are stated in the body of the report.

ALTERNATIVE ACTIONS

A. CONTINUE PRESENT POLICIES

The current state policies (laws and court decisions) on storage and transfer of surface water do not seem to inhibit the development of supplemental water systems. The Nebraska Endangered Species Act may be an exception. By contrast, an absence of legal authority to transfer groundwater for agricultural purposes does inhibit such development. The state policies on water conservation and groundwater-reservoir management are not seen as hindrances to supplemental water developments. The existing level of state funding which might be available for such development is very limited and would not promote rapid or large-scale development of supplemental water supplies. Some sources also believe that both the most inexpensive and the most economically feasible projects have already been built.

B. INTEGRATED MANAGEMENT

Methods of management that integrate the use of water from more than one source suggest alternative actions. An alternative was included in this study which could enhance this method of developing supplemental water supplies in Nebraska.

Alternative 1 (formerly Alternative #4)

Authorize water suppliers to vary surface water and groundwater use fees to achieve a balanced use of each.

C. CHANGES IN WATER RIGHTS

Alternative 2 (formerly Alternative #6)
Authorize groundwater transfer for agricultural purposes to include irrigation, recharge, and surface and underground storage.

Alternative 3 (formerly Alternative #7)
Declare that groundwater may be used to supplement natural flow to meet stream flow needs.

Alternative 4 (formerly Alternative #8)
Remove the preference for junior natural-flow appropriators over senior storage appropriators during irrigation season.

Alternative 5 (formerly Alternative #9)
Develop more specific guidelines as to what is necessary to extend an application for water for a supplemental water project that has not been completed.

D. SOURCES OF FUNDING

Alternative 6 - Alternative 12 (formerly Alternative #10 - Alternative #16)
Increase the level of state funding for development of supplemental water supplies. The proposals for sources of such funding range from new taxes and use fees to increased appropriations and taxes, to the sale of bonds.

Alternative 13 - Alternative 18 (formerly Alternative #17 - Alternative #22)
Increase the capability of local governments, including natural resources districts, to raise funds to develop supplemental water supplies. This could be done through granting authority for new taxes and use fees and new financing methods to include bonds.

E. CHANGES IN EXISTING PROGRAMS

Alternative 19- Alternative 22 (formerly Alternative #23 - Alternative #26)
Change the Natural Resources Development Fund by establishing new criteria for economic feasibility, by allowing grants for revenue-producing projects, and by giving priority to large-size projects and those with integrated management.

Alternative 23 (formerly Alternative #27)
Place a priority on projects funded through the Water Conservation Fund which offset the need for supplemental water development.

Alternative 24 (formerly Alternative #29)
Direct through legislation and funding that the Natural Resources Commission begin to plan and design water-resources projects.

Alternative 25 (formerly Alternative #30)
Encourage construction of water impoundment/roadway joint-use structures.

Alternative 26 (formerly Alternative #31)
Authorize local government to collect payments in lieu of taxes for land which is used in the construction of supplemental water projects.

Alternative 27
Amend Section 37-435(3) and other sections of the Non-Game and Endangered Species Act so that the State Act includes an exemption process and is otherwise consistent with the Federal Act.

F. NEW PROGRAMS

Alternative 28 (formerly Alternative #32)
Direct some entity to develop a plan to obtain and use supplemental water from the Missouri River.

Alternative 29 (formerly Alternative #33)
Institute and fund a type of state public works program to develop supplemental water-supply projects.

Alternative 30 (formerly Alternative #34)
Establish a water development advocacy agency in Nebraska.

Many of the alternatives that are presented in this report should be considered in combination with each other as well as on their individual merits.

Introduction

The purpose of this report is to describe and evaluate legislative and management alternatives that would facilitate the development of supplemental water supplies in Nebraska. In accomplishing this purpose the following objectives were addressed: (1) Identify existing and potential water short areas and water storage locations, (2) Identify sources and methods of water supply augmentation, (3) Identify and evaluate alternative administrative and legislative actions to facilitate water supply augmentation.

A definition of supplemental water begins Chapter 1 of this report. This chapter sets the limits of the study not only by identifying what is supplemental water in this study, but by discussing what is not. Chapter 1 then continues to set the tone for the study by a general discussion of sources and uses for supplemental water.

Chapters 2 and 3 discuss in greater detail, as to locations and quantities, the opportunities for use of supplemental water in Nebraska and the sources of such water. Chapter 3 also outlines the components of a supplemental water supply system and how those components might be used.

The constraints to development of a supplemental water system may come from a wide variety of factors and conditions. Chapter 4 considers impacts which may be hinderances to development and thus are considered as constraints. These impacts include economic, environmental, technological, social, legal, and institutional factors and conditions. Chapter 5 discusses the current policies towards development of supplemental water supplies and presents policy alternatives addressing development. The alternatives are directed towards change in legislation and management. The final chapter also presents possible general impacts of these policy alternatives.

The report includes selected references and sources at the end of each chapter. Seven appendices at the end of the report address: water supplies in streams, existing and proposed storage sites, environmental constraints, Nebraska laws affecting supplemental water supplies, institutional arrangements for water development, the relationship of this policy study to others, and summaries of the public meetings on this study.

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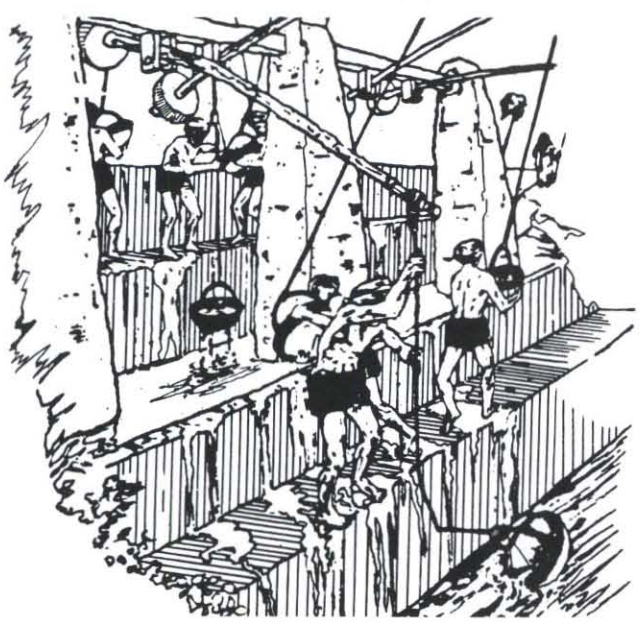
Chapter 1

Supplemental Water

A. SUPPLEMENTAL WATER DEFINED

Supplemental water is additional water provided to supply that which is lacking, i.e., needed or desired. Because water is unevenly distributed in time and space, storage and transportation are the key elements in any strategy to provide supplemental water. In this study, supplemental water is considered to be water which is made available for use within a specific area by moving it from one area to another and/or storing it for use at a later time. Supplemental water can be provided by constructing surface-water reservoirs, by adding to groundwater storage and by importing groundwater or surface water from another area.* The objective of providing supplemental water is to balance the supply from available sources for the various uses.

The concept of supplementing a local limited water supply is as old as civilization. The practices of adding storage to enhance or augment water supply from another source are equally old. Knowledge and technology, however, surely limited human habitation to environs near surface-water supplies from streams, lakes, and springs. Gourds and fabricated containers permitted excursions, not relocation of people. The needs to capture and supplement a given supply through storage undoubtedly led to the digging or enlargement of depressions to catch and hold rain and the construction of primitive rock or earthen dams across small streams. The first direct use of the groundwater reservoir as a sole source of water supply or as a supplement to a surface supply probably was from hand-dug shallow holes in dry stream beds. Technology limited the use of storage in either surface structures or from groundwater reservoirs until historical times.



B. SOURCES OF SUPPLEMENTAL WATER

This report considers a variety of sources and methods for supplementing water supplies. Those which were considered in the study period, but not included in detail in this report, deserve some discussion here. These include using the soil profile as a water source and a location for supplemental storage through conservation practices, reduction of evapotranspiration, weather modification and reduction of losses from surface water.

One source of water is that contained within the soil profile. The soil zone, depth from the surface of two to five feet, is a type of storage reservoir. The supply varies depending upon characteristics of the soil, time and amount of precipitation, and other climatic factors affecting evaporation or plant transpiration. Various conservation methods have been used to supplement or increase the supply of water in the soil profile. Land-treatment practices such as contour plowing, terracing, mulching, and ecofallow provide supplemental water by increasing the available soil moisture for plants. These practices, along with land shaping and leveling, also contribute to groundwater recharge. Quantifying the amounts of supplemental water provided by these methods is difficult. Likewise it is difficult to measure

* Not considered to be supplemental water are natural stream flow that is diverted to riparian land and groundwater used within one mile of the point of withdrawal.

the depletion of streams caused by holding water on the land by land treatment including small farm and watershed ponds. Some studies suggest that the depletion of stream flow caused by land treatment may be significant (Edgar and Sunada, 1977, and Leonard and Huntoon, 1974). Thus, it is desirable and probably necessary to quantify that depletion in order to forecast future water supply and need.

Although the methods of supplementing water storage in the soil zone are recognized as an important element of balancing or integrating water from all sources, the subject is beyond the scope of this study. Rather, this study, in considering agricultural use, will be concerned with supplementing the natural or conservation-augmented supply as outlined above with water from either surface or underground sources.

Three methods of reducing evapotranspiration losses and thereby indirectly increasing the water supply are (1) substitution of crops requiring less water for crops with higher water demand, (2) scheduling of irrigation to meet crop needs, and (3) lowering the water table by pumping from wells in shallow water-table areas, thereby salvaging water which would have been lost to the atmosphere through the processes of evapotranspiration. All three of these methods are to be considered in the water-use efficiency policy issue study (Nebraska Natural Resources Commission, 1984). Evapotranspiration (ET) salvage in shallow water-table areas may be an important element of water management in Nebraska. Evidence suggests that ET salvage may already be an effective though unplanned management practice in the state. The lowering of water levels in shallow water-table areas by deep-rooted plants or by wells reduces evaporation losses from soils wetted by capillary water and by plant transpiration. Space is also provided for recharge from some precipitation events. Both conditions of ET salvage are believed to prevail in large portions of the Platte River basin.

Too little research has been done and too little data collected to understand the ET component of the hydrologic cycle as it relates to water management in shallow water-table areas of river valleys and portions of the Nebraska Sandhills. In theory and from evidence based on Platte River flows, it is probable that the valley lands and vegetation have historically evaporated and transpired large volumes of stream flow and groundwater (Bentall, 1982). The same evidence and theory also suggest that ET salvage accomplished through cropping and intensive groundwater pumping primarily for irrigation has effectively replaced natural withdrawals. Although the consumptive use of water for irrigation is substantial, the net effect since the 1940s appears to be a substitution for some of the losses previously attributable to ET, some lowering of the water table and an increased (although apparently stabilized) annual depletion of stream flow. The flood plain, wet prairies and marshes have largely given away to agriculture in the Platte River drainage basin and this has occurred in part due to lowering of the water table by crops and large-yield wells. Any water-management strategy proposing to provide supplemental water supplies will need to consider ET salvage in shallow water-table areas. However, a more detailed consideration of ET salvage is beyond the scope of this study.

Other potential methods of providing additional water not included in detail in this study are weather modification and reduction of losses from water surfaces. Modification of weather to increase precipitation has been attempted in the plains states but with unproven success. Also, attempts to reduce evaporation losses from lakes and reservoirs by spreading a suppressant film on the water surface have generally had little success. Only limited experimentation with either method has been done in Nebraska.

Effort has been made in Nebraska to provide supplemental water supplies as defined in this study. To date, much of the public effort has been directed to the building of large-size reservoirs (those having a normal storage of 50,000 acre-feet or more). In Nebraska these reservoirs have a combined storage capability of about 3 million acre-feet. Their primary purpose is for irrigation. In addition, much of the 3 million acre-feet of water stored in five reservoirs in the Wyoming part of the North Platte River basin becomes available for use in Nebraska. The water stored in the Wyoming reservoirs was also originally intended primarily for irrigation, although power generation has been added as another important use. In Nebraska, hydroelectric generation, cooling, flood control, groundwater recharge, recreation and streamflow maintenance are either planned, unplanned, or added uses of water from these large existing reservoirs.

In addition to the large reservoirs built primarily for storing irrigation water, a number of medium-size reservoirs of 1,000 to 50,000 acre-feet of storage have been built for flood control, regulating power production and

recreation. Some also supply water for irrigation and most are used for fishing and provide a habitat for wildlife. Many of these reservoirs were constructed by the U.S. Army Corps of Engineers in the Salt and Papillion Creek drainage basins. Other medium-size reservoirs have been built by the U.S. Soil Conservation Service and the natural resources districts. Thousands of small-size reservoirs of less than 1,000 acre-feet of storage have been constructed as farm ponds, grade-stabilization structures and irrigation reuse pits. A few small-size reservoirs have been constructed for municipal use. Although all of these small-size and medium-size reservoirs provide benefits including supplemental water supply, they also deplete annual streamflow because they lose water by seepage and evaporation. However, the losses by seepage recharge the groundwater reservoir.

Many other potential surface sites for storage exist in the state. Those which have been studied to date are identified in Chapter 3 of this report. Although surface sites are numerous, perhaps the greatest potential for water storage is underground. Storage in the groundwater reservoir to provide supplemental water probably is of greater importance in Nebraska than in most other states. Because of unique geologic conditions that led to an accumulation of thick deposits of silt, sand, and gravel, much of Nebraska is underlain with a vast underground reservoir. Water stored in groundwater reservoirs or space above such reservoirs can provide storage for later use. Water thus stored is less vulnerable to loss from evaporation than in water stored in surface-water reservoirs.

The concept of reservoir operation, both surface and underground, is that of storing during periods of wet years and large overland runoff and of use through drawdown during peak demands and/or dry years. The opportunity and challenge are to integrate and manage water in both surface and groundwater reservoirs.

That water can be stored in groundwater reservoirs has been established in Nebraska and elsewhere. Experimental recharge through wells has been attempted by the City of Lincoln and in Hamilton County. One reservoir has been constructed in the Little Blue Natural Resources District with groundwater recharge as a main benefit. Others have been proposed. The most dramatic example of potential for underground storage is the groundwater mound that has developed south of the Platte River from near Sutherland to Minden. Inadvertent seepage losses from the Nebraska Public Power District's Sutherland Reservoir and canal system through Lake Maloney, coupled with that from canals, reservoirs and irrigated lands of the Central Nebraska Public Power and Irrigation Districts project, account for an estimated increase in groundwater storage of 10 million acre-feet.

Most other surface-water projects also have contributed to groundwater storage. One area in particular provides an example of the principle of conjunctive use, i.e., integrated use of surface water and groundwater. Irrigation in Dawson County had an early (1890s) reliance on water diverted from a limited Platte River supply. Irrigators there progressed to using water from private wells constructed since the 1930s which are supplemented with water stored in Lake McConaughy through rights that were acquired. The net effect has been to balance water supplied from streamflows and storage releases with intensive groundwater withdrawal by wells and by crops through subirrigation. Water levels have been maintained by the distribution of the surface water. Drainage problems have been minimized by groundwater use.

C. "OPPORTUNITY" AND "NEED" FOR SUPPLEMENTAL USE

Supplemental water cannot be viewed without consideration of the available water supply and opportunities for use. For purposes of this report "opportunity" is defined as a situation where a party would be likely to utilize water not currently available at a particular location. Whether it is wise to take advantage of that opportunity, in terms of cost or other factors is a matter to be evaluated in connection with the Chapter 4 discussion of constraints and impacts.

Need refers to the degree of good that water can do for a party or group if supplied. Water that is judged available and needed by one group may not be judged in a like fashion by another. Competition for an available water supply may result. Water needs come about because someone or some group perceives a water shortage for one or more particular uses in a specific area. Thus, need may be identified. The need may range by degree from that which is wanted or desired to that which is a requisite. Some needs may continue to exist indefinitely necessitating adjustment to an existing supply. Another need might await its turn. Implementation of an action to provide a supplemental supply might be delayed until one or more conditions change or are changed and favorable circumstances permit the action to take place. In other cases a need, identified as a water quantity or quality problem, might not be sufficiently serious to warrant action until some time in the future as conditions worsen.

Another factor in deciding whether to fulfill a need is evaluation of the constraints and impacts identified in Chapter 4. Economic (or financial) evaluation compares the economic cost of fulfilling a need to the economic benefit it provides. Cost of developing the supplemental supply plus the costs reflecting the adverse impacts can be compared to the willingness of project beneficiaries to pay for the supplemental water. This willingness to pay presumably reflects the economic benefits conferred by the project. (Payment in this context includes direct water-use charges and indirect charges through increased property taxes in the project area.) This financial approach to evaluating

supplemental water-supply alternatives has been used in evaluating costs and benefits of state and federal grants for water-development purposes. This method also provides a means to evaluate competing water projects: those with the highest net benefits are those best meeting supplemental water supply "needs."

This leads to the issue of how supplemental water-supply projects are financed. Generally, direct project beneficiaries (e.g., irrigators purchasing project water) cannot afford or are unwilling to bear total the project costs. Therefore, direct state and federal grants are made for water-development purposes on the theory that the general public (federal, state or regional) indirectly benefits economically and in other ways from these projects. These indirect benefits have been difficult to quantify, however, leading to controversy regarding whether indirect benefits are as great as project proponents believe they are. This issue will become more prominent when federal financial assistance for water projects is made contingent on substantial state and local financial contributions. Politically, this means that state and local taxpayers will have to be persuaded that the indirect benefits from water projects will justify the significant public expenditures (and the associated tax increases) required if additional federal or state water projects are to be constructed in Nebraska.

D. AVAILABLE WATER SUPPLY

Just as it is difficult to define water needs, it is equally as difficult to determine if, when, and where an available supply might exist for supplemental use. Available water might be any water in sufficient quantity and of satisfactory quality for a specific use that is surplus to existing uses. The most obvious type of surplus water generally considered available for supplemental use is flood flow. Flood flows are a primary source of water for storing in most existing surface-water reservoirs. A dam on any stream or drainage could store future flood flows. Most surface-water reservoirs also store base flow of streams, and that is the main source for a few reservoirs. Water is available in streams as both flood and base flow that could be stored and/or transported. Water is available also from the groundwater reservoir for supplemental use. Both types of available water are identified in this report in Chapter 3. The same test of beneficial and adverse impacts as applied in judging uses must be applied in judging the availability. In addition, tests of costs and water rights apply.

Obviously there is a limit on the water supply available to provide supplemental water no matter who makes the judgment. Just as precipitation is the ultimate source of all water supplies, the ultimate constraint or development and management of supplemental water may be the statewide or regional precipitation. Amounts of annual precipitation range between 80 and 100 million acre-feet in Nebraska. The distribution of precipitation is uneven across the state and on the long-term average increases uniformly eastward across the state in amounts of about 15 inches in the extreme west to about 35 inches in the extreme southeast. State-wide the longterm average annual precipitation is about 22.8 inches, about two-thirds of which falls during the growing season. Although much of the water from precipitation is evaporated or is transpired by plants (about 90 percent in an average year), temporary storage in the soil reservoir in the state can range between 8 and 25 million acre-feet. Some precipitation moves to streams and is diverted, stored, evaporated, or leaves the state. The amount of water leaving the state annually ranges widely from below 5 million acre-feet in extremely dry years to more than 15 million acre-feet in extremely wet years. The average is about 7 to 8 million acre-feet. Part of the Nebraska supply originates as precipitation falling in adjacent regions to the northwest, west and southwest. In this study, the availability of water for supplemental uses was considered to start after precipitation found its way into surface flows or the groundwater reservoir.

The flow of the Missouri River and storage and releases from the main-stem reservoirs in Montana, North Dakota, and South Dakota constitute a major potential water supply. The combined storage capacity of the six reservoirs is huge, more than 70 million acre-feet. Water moving into the state as streamflow as a result of precipitation in South Dakota, Wyoming, Colorado, and Kansas also constitutes a potential supplemental supply. Nearly 2 million acre-feet of streamflow originates primarily as snow melt in Wyoming and Colorado and enters the state through the North and South Platte rivers. However, considered water comes across the state line as storage releases from out-of-state reservoirs which were built for project use by irrigation or irrigation and power districts. Additional water enters the state as return flow from water use in the upstream states.

Although the South Platte River and North Platte River drainage basins are about the same size, the amount of water entering the state via the North Platte River or canals at the Nebraska-Wyoming state line averages about 1.5 million acre-feet annually while only slightly more than 300,000 acre-feet annually comes into the state through the South Platte River at the Nebraska-Colorado state line. Nebraska benefits indirectly from water imported into the South Platte River basin from the Colorado River and the North Platte River basins. In recent years such importations have amounted to about 300,000 acre-feet annually. Although this amount approximates the amount entering Nebraska, most of the imported water is used consumptively in Colorado. Natural flows, irrigation return flow and other sources provide the water that enters Nebraska. Natural evapotranspiration losses are large in the South Platte River drainage basin in Colorado where consumptive use through irrigation is relatively high.

Of the remaining 2 million acre-feet of stream flow entering the state, about 100,000 acre-feet enters the state from other streams originating in Kansas, South Dakota, Colorado, and Wyoming. The flow into the state from the Republican River and the Niobrara River and their tributaries constitutes most of the remainder (Bentall and Shaffer, 1979). Flows are further discussed in Chapter 3 and Appendix A of this report.

Water in streams can be considered supplemental water especially in the losing reaches of streams. Most streams in Nebraska are groundwater drains, not sources of groundwater recharge, and overland runoff is a major component of flow. Public water supply and irrigation wells do tap groundwater reservoirs adjacent to the few losing reaches of streams. In most of these cases, the streams do not provide significantly different amounts of annual recharge under conditions of continuous flow or interrupted flow. Some streams of small annual discharge on the semi-arid plains of western Nebraska are probably exceptions to this generality. Where subirrigated lands are adjacent to streams, the water-level under these lands ordinarily is maintained by groundwater moving toward or parellel to the stream and not be seepage away from it. On a statewide basis, then, the seepage from streams as a source of groundwater recharge or supplemental supply is quite small and probably cannot be increased by any great significant amount.

The water stored in or the water added to the state's groundwater reservoir is the largest potential source of water available for supplemental use in the state. The supply is estimated to be more than 2 billion acre-feet of good quality water (Engberg and Spalding, 1978) at relatively shallow depths. This is discussed further in Chapters 2 and 3 of this report and in the *Policy Issue Study on Groundwater Reservoir Management* (Nebraska Natural Resources Commission, 1982). Like precipitation, streamflow and stored surface water, groundwater is not evenly distributed within the state or within any region. Geologic conditions have naturally limited the occurrence and availability of groundwater around the northern and southern margins of the state and in the glaciated eastern part of the state.

The amount of groundwater stored in different areas of the state has been changed because of water use. These changes, which are the results of groundwater withdrawal by wells and surface-water storage and distribution, have been documented by observation-well monitoring in a cooperative program of the U.S. Geological Survey and the Conservation and Survey Division, IANR, UN-L since 1930. Many other federal, state, and local agencies have contributed data and resources to the program. Reports containing maps depicting progressive changes in water levels have been prepared since 1963 and are now published annually (Johnson and Pederson, 1982). Although changed in geographical distribution, the total amount of groundwater in storage within the state has changed little since the first settlers arrived.

Awareness of Nebraska's large store of the available groundwater developed slowly. Awareness of the opportunity to use the storage capacity of the underground and to integrate that storage with surface-water storage for various uses will await general recognition by the public.

E. USES OF SUPPLEMENTAL WATER SUPPLIES

Irrigation has been and will continue to be the largest user of water in the state. The vagary of the climate was recognized in accounts of the early explorers and settlers and has been documented by more than 100 years of weather records. This condition requires supplemental water for sustained crop production in most of the state. Groundwater is the largest source of water used for irrigation in Nebraska. Although, as defined

in this study its use for irrigation is generally not considered to be supplemental water. The ratio of acres of land supplied by groundwater to that supplied from surface sources currently is about 6.5 to 1. Some land is served from both sources. Although some irrigation is from water diverted directly from a stream, most irrigation is from water stored in surface-water reservoirs or the groundwater reservoir. Irrigation, in the future, almost surely will be the single largest demand for supplemental water. For this reason conservation of supply, through various means, will continue to have a larger impact when implemented for this use than others. The opportunity to meet some perceived needs is believed to exist. Potentially, irrigation is the biggest competitor for supplemental water.

The practice of supplementing municipal supply by importation of water stems from local over-development of the supply in some cities in the 1930s, notably Lincoln, Seward, and Falls City. Later many other cities went outside of their corporate limits to develop and import water to supplement either a local groundwater supply, or as in the case of Omaha, a Missouri River supply. The *Policy Issue Study on Municipal Water Needs* (Nebraska Natural Resources Commission, 1983) described municipal water supply quantity and quality problems and needs. Some of these may have to be met by importation, by augmentation from surface-water reservoirs, or through additions (artificial recharge) to the groundwater reservoir. Supplemental water in terms of available water should not prove to be a limiting factor in providing for municipal use. However constraints such as the cost of importing supplies could have an impact in some cases.

Water for rural domestic and stock uses traditionally has been an individual responsibility. Groundwater from wells has been the main source of water supply, although livestock watering from streams has been an alternate supply. Many communities have loading facilities for hauling rural domestic annd stock water. Seasonally and in drought years, water hauled to the farm ponds and fabricated storage units have supplemented the supply in areas where the local supply is limited by quantity or quality. Unfortunately, in seasons or years of deficient precipitation, both groundwater and surface supplies may be insufficient for needs in part of the state. Rural water districts and private pipeline systems import water, primarily groundwater, to supplement the local supply. However, most systems constructed to date have limited capacities and capabilities.

Importation of water for domestic, stock, and municipal, including industrial, uses will continue to be the primary method of supplementing supplies for those uses. Conservation of water by metering, by reducing water use for lawn watering, through reuse and by pricing can contribute to extending the supply. One practice which has not had popular appeal but has been implemented to some degree is that of joint use of a water supply and facilities by two or more communities or by a community and a rural water district. The joint sharing approach from an imported source will likely become increasingly attrative as an efficient means of supplementing an inadequate supply.

Water for cooling purposes in certain industrial or power applications can be a consumptive use of water. These uses could become an increasingly significant demand on the available water supply. They are being addressed in the water/energy policy issue study (Nebraska Natural Resources Commission, 1984). Such needs have been and will continue to be met by direct diversion from streams, by wells or by supplemental water.

Hydro power traditionally has been an important source of electricity in the state. Although direct flow released from low dams produced much of the early electrical power in the state, most of the hydroelectric power generated within the state now is from supplemental water supplied by storage and by importation and sttorage. The publications *"Availability and Use of Water in Nebraska, 1975"* (Bentall and Shafer, 1979) and *"An Inventory of Public, Industrial, and Power-Generating Water Use in Nebraska, 1979 and 1980"* (Lawton, Veys and Goodenkauf, 1983) describe the current uses of water for hydroelectric power as well as municipal and industrial purposes. Any increased use of water for hydroelectric power generation will almost surely involve the use of supplemental water. The joint use of storage releases with other uses appears to be feasible.

Another use of water which may become significant in the future is related to the energy industry. This would include water for mineral extraction, processing and transportation. Supplemental water in or from Nebraska may be required for any of these purposes. The water/energy policy issue study will consider this potential in detail.

The public perception of the water needs for fish, wildlife and recreation ranges widely. Perhaps of all the needs or uses for water as considered in this report, the needs and uses for fish, wildlife and recreation are the most difficult to describe and quantify. Changes in water use for recreation, fishing, and wildlife have occurred as the result of water development and management. The creation of supplemental water supplies by storage, particularly in large surface reservoirs, has contributed significantly to an increase in recreational opportunities. Flat water facilities for boating, swimming, and water skiing and reservoirs for fishing are not equally distributed within the state. Water storage and stream diversion have had both positive and adverse impacts on terrestrial and aquatic habitat. Significant changes in plant and animal communities have occurred in some flood plains; fisheries have been reduced in some stream stretches and enhanced in others; and the riverine habitat for some kinds of migratory water fowl has been reduced in some areas and enhanced elsewhere.

Supplemental water for navigation was considered

in the course of the study. Although the use of water for navigation on the Missouri River was recognized as being important to Nebraska, supplying water for that use is primarily a federal and multi-state responsibility.

F. THE FUTURE OF SUPPLEMENTAL SUPPLIES

Supplemental water as defined in this study and discussed in the report provides a framework for potential investment in the future. The report does not identify specific projects or a specific available water supply. The report does suggest a new class of water that has not hitherto been formally recognized in Nebraska. For want of a better term that classification of water is "supplemental water." Supplemental water as defined in this study is distinguished from water naturally occurring in the atmosphere and on or in the ground. It is that water which people have made available or will make available to meet their wants. In regards to storage, the use and management of supplemental water has been called conjunctive or integrated use and is discussed later in the report.

Not all future proposals for providing a supplemental water supply will be implemented because of factors or conditions identified as constraints in this report. Many projects proposed will be expensive. As has occurred in the recent past, any major project will come under close scrutiny by a cost-conscious and environment-conscious public. Therefore, other ways of stretching the supply may be very attractive. The methods of augmenting a limited supply through conservation should be encouraged and even demanded as a part of the management of water in Nebraska. However, presently there are not available alternatives to providing a supplemental water supply, except as defined and discussed in this report. An exception might be weather modification which may hold some promise for small but significant increases in precipitation in the future. Such additional water resulting from weather modification would become a part of the available supply to be stored, transported and used. However, at this point the effectiveness and impacts of weather modification technologies are uncertain.

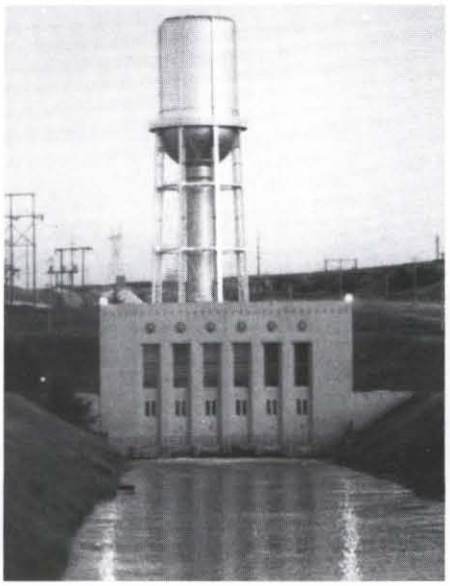
The future for sustained use of water to maintain and enhance our economic and recreational base and to preserve or enhance the environment is as bright as the citizens of Nebraska wish it to be and can afford. Related to the decisions Nebraskans will be making is the underlying consideration of population, the number of people in the state and where they will be located.

The pressing need for supplemental water supply is presently confined to small, localized areas. This report and other policy issue reports have recognized existing and emerging problems relative to inadequacy of supply. Extensive time frames may be required to study, obtain funds, and implement proposals to use supplemental water. The alternatives presented in this report therefore address changes in water policy that singly, or in combination, could establish the future legal, institutional, and economic framework for state policies on supplemental water.

Constraints to providing supplemental water are discussed and impacts of alternatives suggested are described. Because the natural, social, and economic processes are ever-changing, the judgement of constraints and impacts are only as good as the state of the knowledge. Required will be the determination to continually evaluate water availability and impacts of use through research and data collection. Also required will be the determination to develop a broad base of public understanding and awareness.

Economics is recognized as being the single most important factor by which needs and alternatives to provide solutions have been judged. Economics may also be uppermost as one of the tests applied in establishing priorities for implementation of proposals in the future.

The public through the political process will make the final decisions.



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Chapter 2

Supplemental Water Use

The purpose of this chapter is to identify, in general terms, the opportunities for use of supplemental water in Nebraska. Opportunities, for purposes of this chapter, are situations where supplemental water could be used, even though economic, environmental, or other factors may constrain such use to the point that it is judged not worthwhile. For instance, lack of water and suitable lands may create an opportunity to profitably use water for irrigation once it has been transported to some parts of the state. However, the cost of transporting water to that area may be such a constraint that it is not considered a worthwhile expenditure. Thus, "opportunity" refers to an ability to use available water once it is provided to the site.

Four situations will be discussed which demonstrate such opportunities. They are the precipitation pattern, areas of groundwater decline, areas with potential for irrigation development based upon land suitability, and general areas with opportunities for specific uses.

A. PRECIPITATION PATTERN

Perhaps the major situation in Nebraska which creates an opportunity to use supplemental water is the precipitation pattern, both in space and in time. The key word in both dimensions is variable.

Figure 2-1 indicates the mean annual precipitation in the state by area for the years 1941 through 1970. Annual average water requirements for maximum yield by crops vary from about 25 inches for corn to 22 inches for grain sorghum and soybeans (USDA, 1971). This quantity is needed in the growing season and often during specific times in the growing season. Some of the requirement may be met by stored soil moisture. However, most of the requirement must be met by precipitation which may not be available totally to crops because of evaporation, runoff and groundwater recharge. Further, as Figure 2-1 shows, many areas of the state will not receive enough precipitation annual-

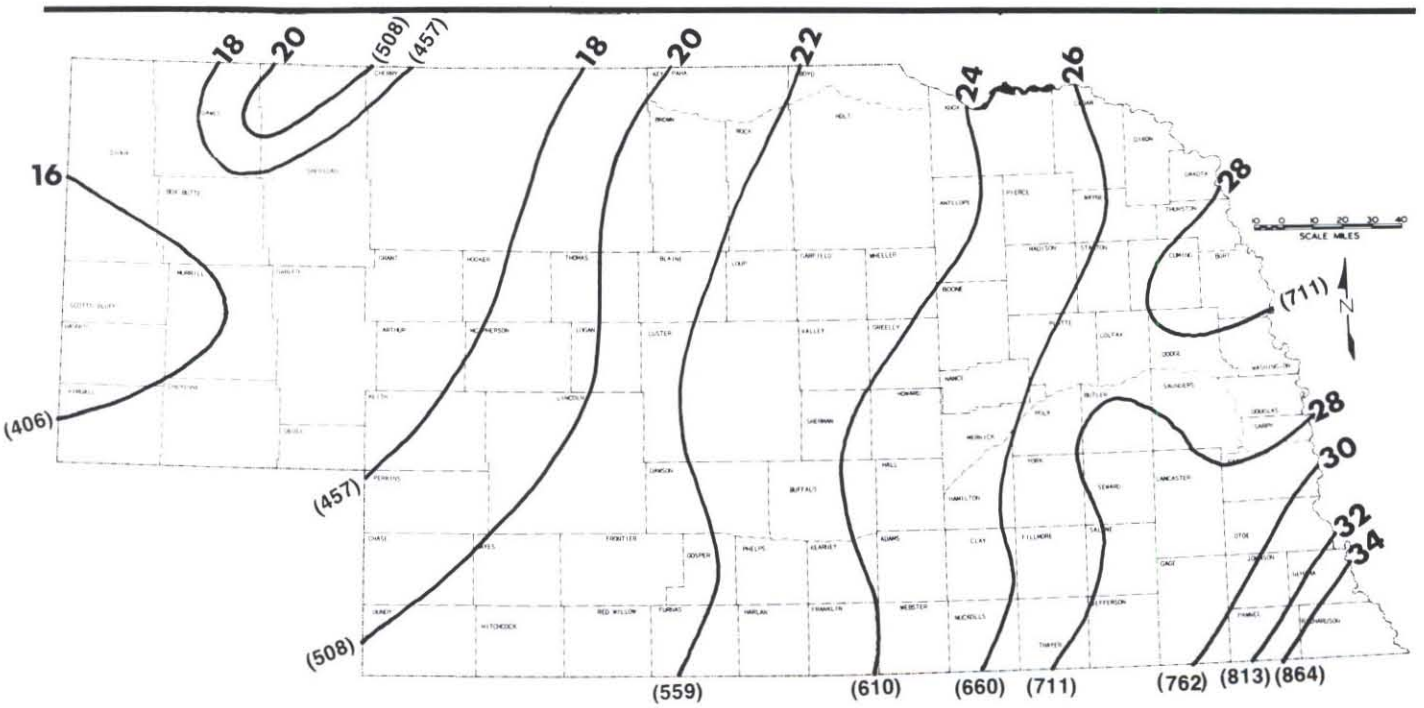
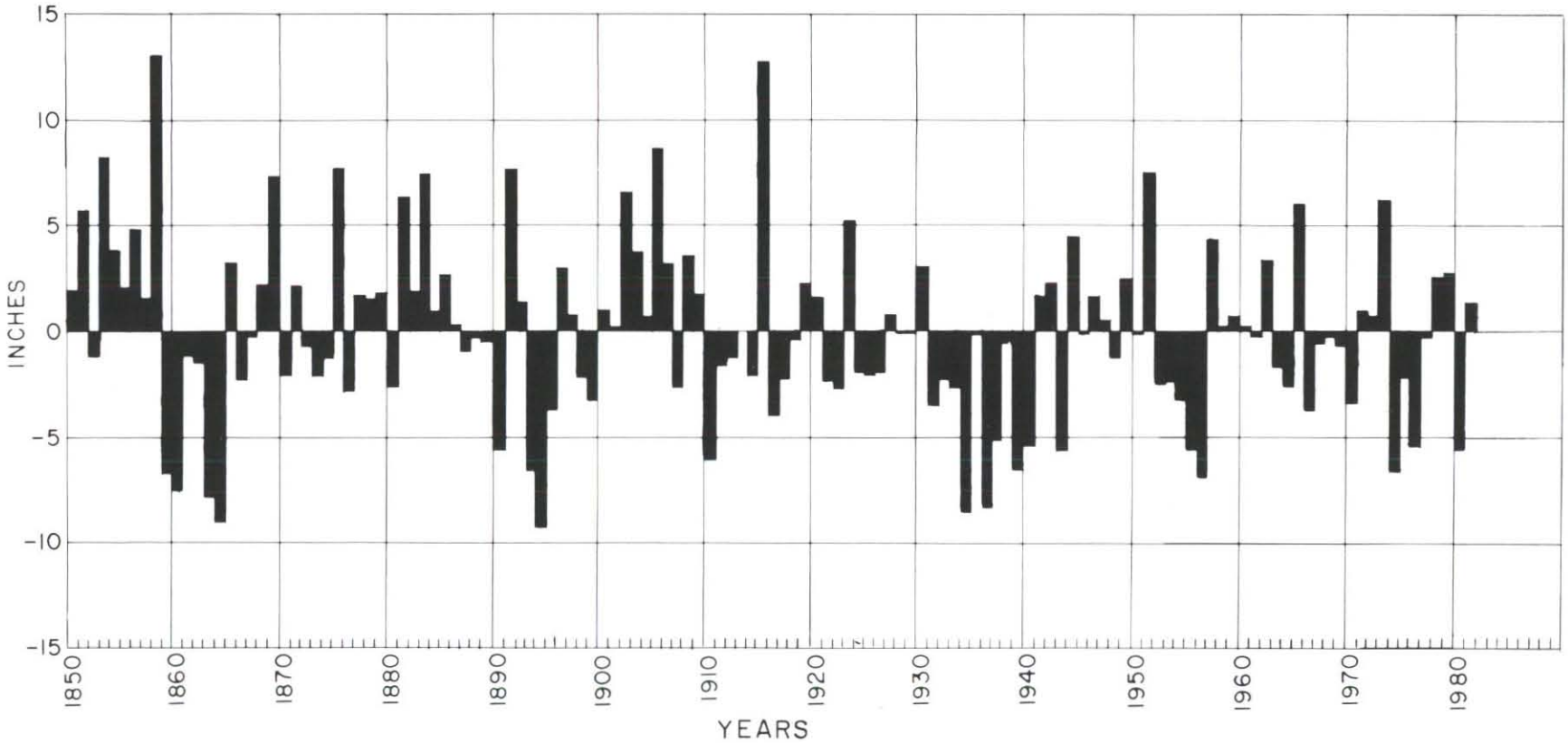


FIGURE 2-1

MEAN ANNUAL PRECIPITATION IN INCHES (MILLIMETERS) BASED ON THE PERIOD 1900-1979

FIGURE 2-2
ANNUAL AVERAGE DEPARTURES FROM AVERAGE ANNUAL PRECIPITATION IN NEBRASKA, 1850-1982



Average annual precipitation, 22.77 inches

ly to meet the crop requirements. Therefore, depending on the crop it is clear that many areas of the state require additional water to meet these requirements in an average year.

The variation in spatial distribution of precipitation is only part of the problem. The extreme variation in precipitation from year to year and month to month forms another pattern which creates an opportunity to use supplemental water. For instance between 1931 and 1979 the two driest years varied from the state's average precipitation by 8.26 inches short in 1934 and 8.17 inches short in 1936. For the same period the two wettest years varied by 7.60 inches over in 1951 and 6.50 inches over in 1977 (Myers, 1980). Figure 2-2 charts these annual departures in the state for a period from 1850 to 1979 and thus is a graphic demonstration of the opportunity to use and to store supplemental water in Nebraska.

B. AREAS OF GROUNDWATER DECLINE

Nebraska is a state rich in both surface water and groundwater. Chapter 3 will describe this in detail. However, there are areas in the state which are experiencing water-level declines since predevelopment. Predevelopment water level is the approximate average water level that existed in a well prior to any development that significantly affected water levels in the vicinity at the well. An annual report with maps on water-level changes is prepared by the Conservation and Survey Division, University of Nebraska-Lincoln and the U.S. Geological Survey (Johnson and Pederson, 1982). That document shows these declines in detail. Figure 2-3 shows these declines for 1981 at a detail which is generalized by township. These townships are areas where the current demands being placed upon the groundwater reservoir are large. Without improved management of the groundwater including severe reductions in present use and/or the introduction of supplemental water, these areas at some point in the future will be unable to support their current level of water use.

C. AREAS WITH POTENTIAL FOR IRRIGATION DEVELOPMENT

The opportunity for supplemental water development in the state (provided no constraining factors are present) is evident from an examination of the land's potential for irrigation development. Figure 2-4 shows by township the maximum irrigation development based on land suitability. The land suitability was derived from 1:250,000-scale soil association maps which consider soil type and slopes. These maps were developed and published by the Conservation and Survey Division, University of Nebraska-Lincoln and the U.S. Department of Agriculture Soil Conservation Service (Conservation and Survey Division, 1981). In Figure 2-4 a "well equivalent" is an installation necessary to irrigate one quarter of one section (160 acres). A well equivalent is similar to the average current center-pivot system as related to the area irrigated. It also acknowledges technology of the center-pivot or other sprinkler systems allows for irrigation on those lands generally not adaptable to gravity systems.

The source for the well equivalent can be either groundwater or surface water. The map does not consider the capabilities of the underlying groundwater reservoirs. A comparison of Figures 2-3 and 2-4 shows high irrigation potential in areas of water-level decline. Figure 2-5 presents groundwater in storage in Nebraska. Comparing this map with Figure 2-4 demonstrates that some areas of high potential for irrigation development have very little groundwater in storage. These areas with high irrigation potential and limited water supply are prime locations for opportunities to use supplemental water supplies if they can be provided in view of constraining factors.

D. AREAS WITH OPPORTUNITIES FOR SPECIFIC USES

A third situation which demonstrates opportunities for use of supplemental water is a statewide review of opportunities for specific uses and the areas where they occur. Six specific uses for supplemental water are considered: irrigation, municipal, livestock and rural domestic, electric power, industrial, and fish, wildlife and outdoor recreation. Figure 2-6 shows at a drainage-basin level where these uses could occur. The following discussions give some detail about the use and about locations in a basin where the use might occur.

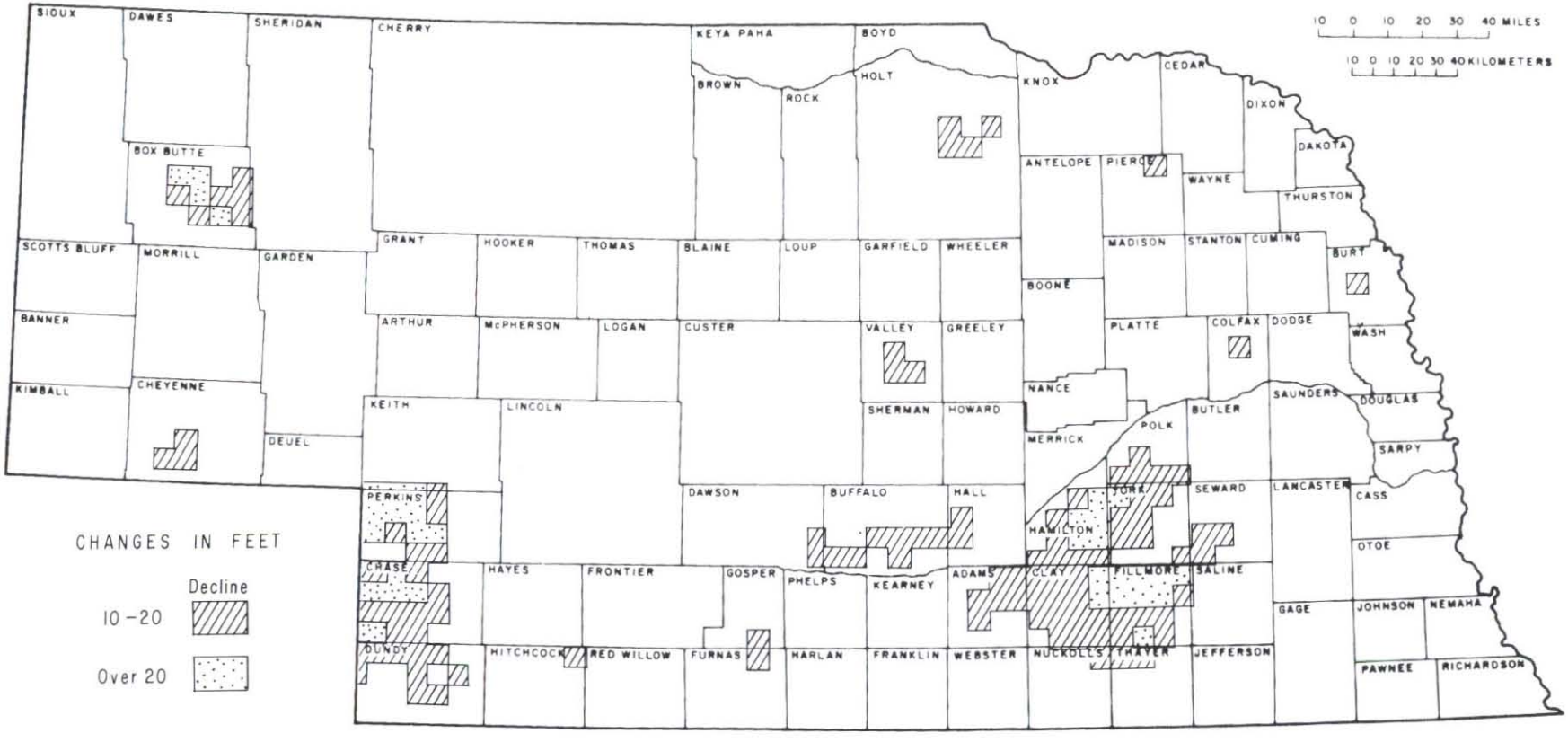
1. Irrigation

Chapter 1 of this report and Sections A and B of this chapter have already identified this use as a prime candidate for using supplemental water supply. Figures 2-3, 2-4, and 2-5 identify both existing and future locations in the state for the use. Only two drainage basins, the Missouri tributaries and Lower Platte, have a combination of land suitability and water-supply limitations that might not require supplemental supplies. In many other basins the opportunity for use would not be basin-wide, but would be restricted to areas as small as a township (36 square miles) or two. Both surface water and groundwater could serve as the source of supplemental water for this use.

2. Municipal

The opportunities for municipal use of supplemental water supplies are based upon both quantity and quality criteria. In the future, supplemental water may be needed for quality reasons at a basin level such as in the Middle Platte or in communities in southeast Nebraska. Quantity problems may require additions to existing supplemental systems such as for Omaha and

FIGURE 2-3
TOWNSHIPS WITH SIGNIFICANT WATER LEVEL DECLINES SINCE PREDEVELOPMENT



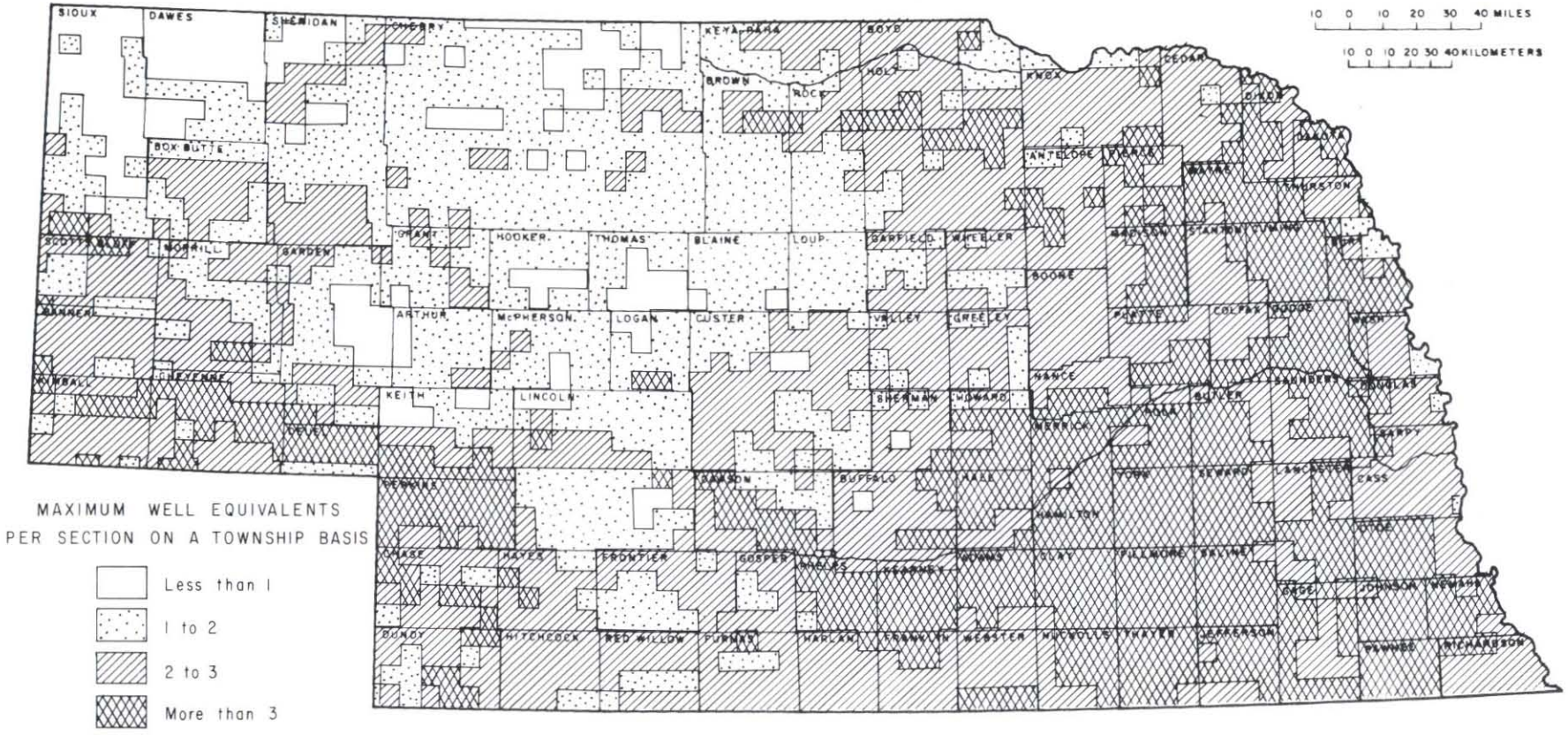
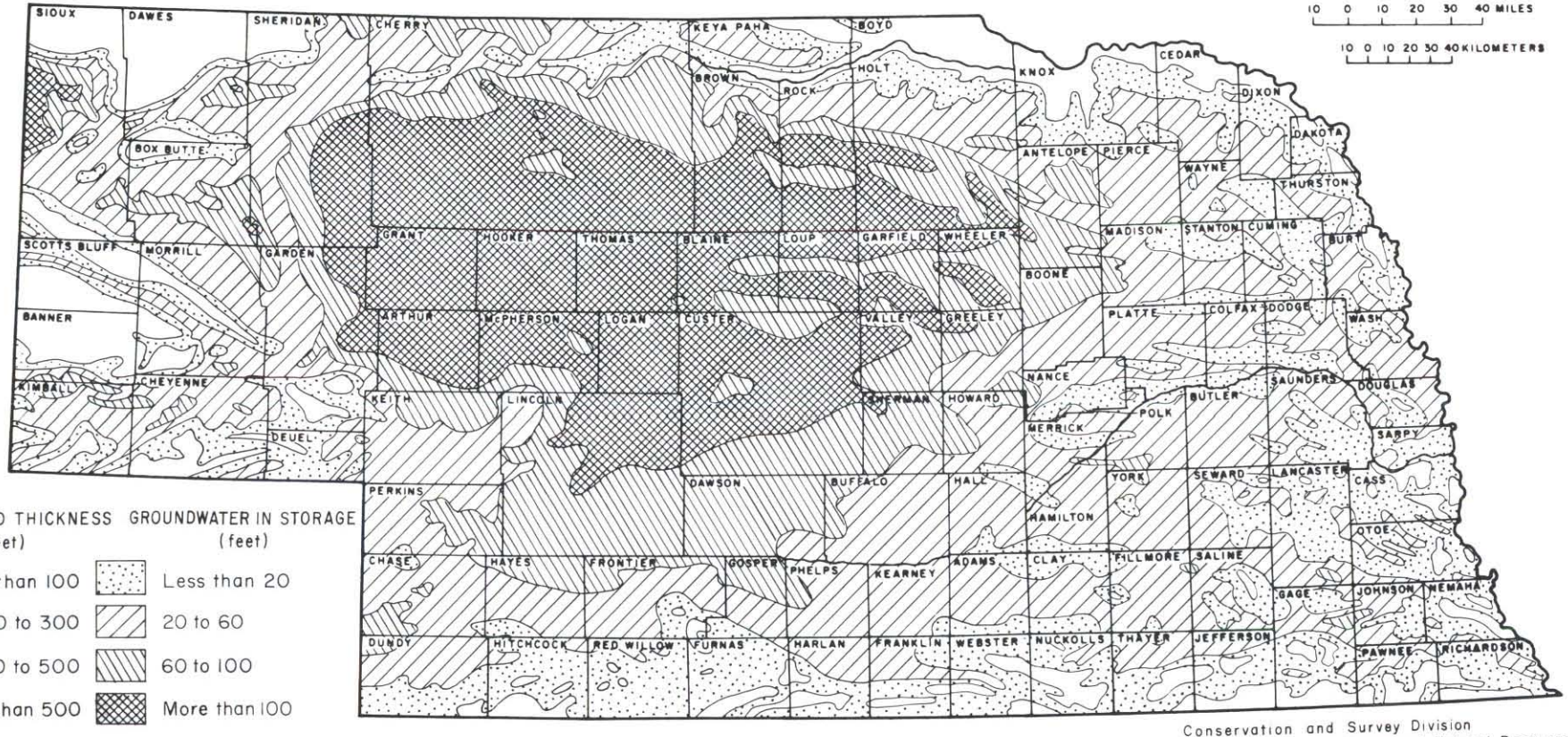


FIGURE 2-4

MAXIMUM IRRIGATION DEVELOPMENT BASED UPON LAND SUITABILITY

FIGURE 2-5

GROUNDWATER IN STORAGE IN THE PRINCIPAL GROUNDWATER RESERVOIR



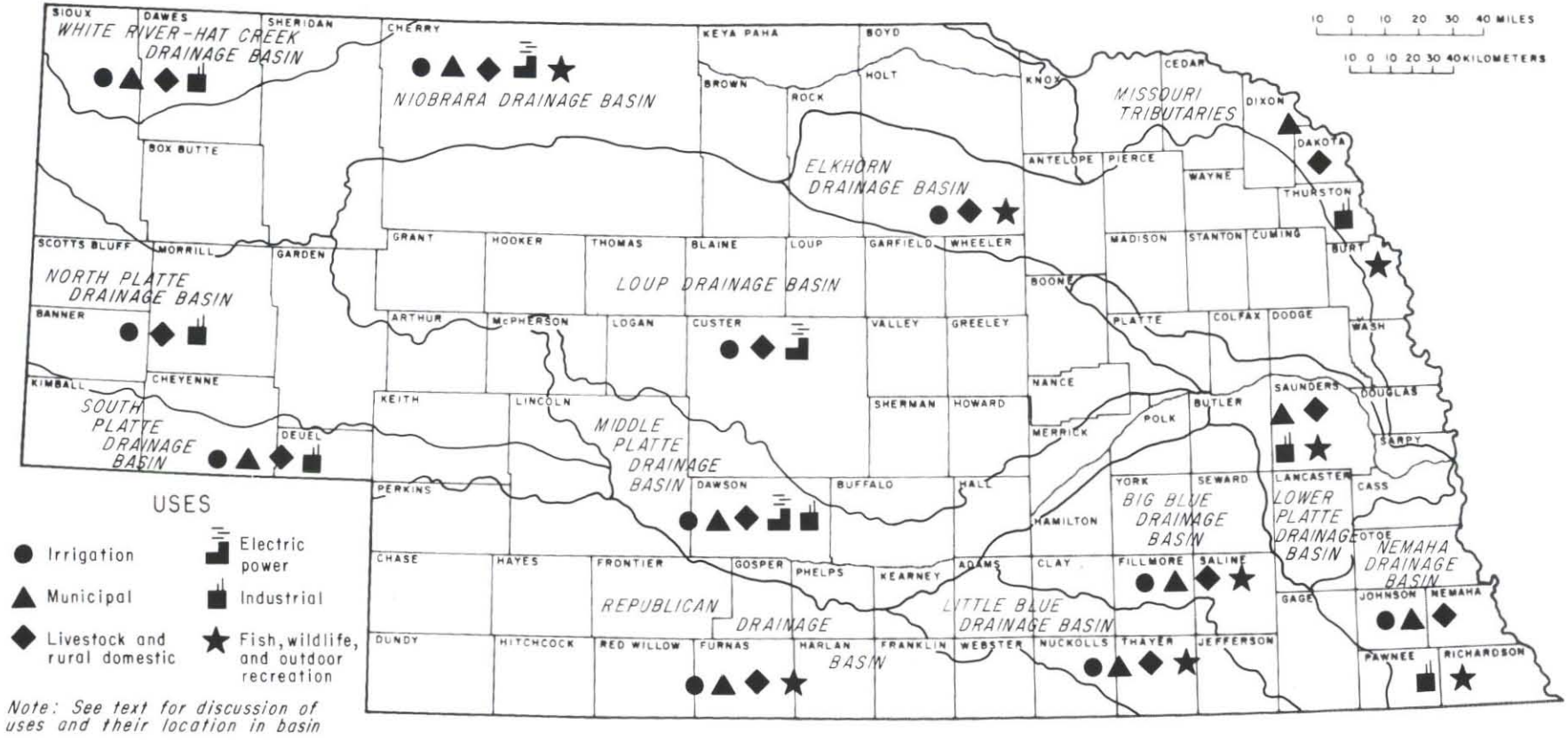


FIGURE 2-6

OPPORTUNITIES FOR SPECIFIC USES OF SUPPLEMENTAL WATER BY BASIN

Lincoln. Irregular groundwater supplies may require supplementing as in the Nemaha basin and Knox County where rural water systems already supply communities. The opportunities for use in most other basins are located in specific communities where local groundwater reservoirs are, or will become, inadequate to meet the quantity requirements of the community. This forces the development of new well fields (supply) at distances from the community which as defined in this report become supplemental (over one mile). This use is discussed in detail in the *Policy Issue Study on Municipal Water Needs* (Nebraska Natural Resources Commission, 1983).

3. Livestock and rural domestic

With the exception of the lower parts of two drainage basins, Loup and Big Blue, the livestock and rural domestic uses on farms and ranches may require supplemental water supplies. This use opportunity or need does not occur basin-wide. It may be isolated to a farm, range, or pasture. Often, as in the White River-Hat Creek, Missouri tributaries, Elkhorn, Lower Platte South, and Nemaha drainage basins, it occurs in large enough areas to make rural water systems feasible. In many cases the opportunity for use can exist due to quality as well as quantity problems. This use can be met with supplemental water from surface water and groundwater sources.

4. Electric power

Two basins, Niobrara and Loup, contain areas that have been identified as presenting an opportunity to use supplemental water for generation of electric power. Recently, one facility was proposed in Box Butte County to use supplemental groundwater from the Loup drainage basin. The central area of the Loup basin is also the location of a potential generating facility that might use groundwater or surface-impounded water. Another proposal would have developed surface-water storage on the lower reaches of the Loup River to further supply an existing supplemental water project used for hydroelectric power generation. Many existing surface-water storage facilities are being considered for modification to allow hydroelectric power generation. One facility, Kingsley Dam, is being so adapted now. It is hard to predict where future opportunities may occur.

5. Industrial

Figure 2-6 identifies some basins where the opportunity to use supplemental water for industrial purposes may occur. This opportunity usually occurs where the same opportunities for municipal use occur for the same reasons. However, this is not always the case, as in western Scotts Bluff County where industrial requirements recently presented an opportunity for supplemental supply in a location removed from municipal supplies. In some instances water quality may create an opportunity for supplemental supply to meet industrial needs.

6. Fish, wildlife, and outdoor recreation

Historically, fish, wildlife, and outdoor recreation benefits from development of supplemental water supplies have been largely incidental to projects which were constructed for other purposes. Some examples of exceptions to this have been: (1) pumping from a well into Walgren Lake in Sheridan County to overcome water-quality problems, (2) pumping from wells into south central Nebraska Rainwater Basins to disperse waterfowl during spring migration periods by maintaining habitat quality, (3) pumping from the Little Blue River to maintain Crystal Lake near Ayr in southeast Adams County, (4) holding and releasing cooling water from power production into Lake Hastings near Hastings in Adams County and (5) constructing Oliver, Maskenthine and Willow Creek reservoirs with recreation as a prime benefit.

Fish, wildlife, and outdoor recreation objectives will be met by future supplemental water-supply developments on a basis similar to that which has occurred during the past, i.e., primarily incidental to construction of flood control and/or irrigation water-supply reservoirs. The greatest needs for water to support reservoir and lake fishing and water skiing and power boating are in the recreation-planning regions encompassing the eastern one-third of the state (Nebraska Game and Parks Commission, 1979). However, virtually all new waters created in any portion of the state has potential and should be evaluated for management potential for these purposes.

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2-2. Conservation and Survey Division.

2-3. Nebraska Natural Resources Commission, 1982, *Policy Issue Study on Groundwater Reservoir Management,* Lincoln, p. 37.

2-4. Nebraska Natural Resources Commission, 1982, *Policy Issue Study on Groundwater Reservoir Management,* Lincoln, p. 25.

2-5. Nebraska Natural Resources Commission, 1982, *Policy Issue Study on Groundwater Reservoir Management,* Lincoln, p. 3.

2-6. Conservation and Survey Division.

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Chapter 3

Supplemental Water Supply

The three basic components that may comprise a supplemental water-supply development are discussed in this chapter. The first section identifies sources of surface water and groundwater supplies in Nebraska. The second section outlines methods for transfer of supplemental water. Finally, the third section discusses the potentials for surface-water and underground-water storage in the state. This study does not identify specific supplemental water projects by location of source, storage or use. However, a wide range of sites is presented in the third section which have been studied for surface water storage.

A. SOURCES OF SUPPLY

1. SURFACE WATER

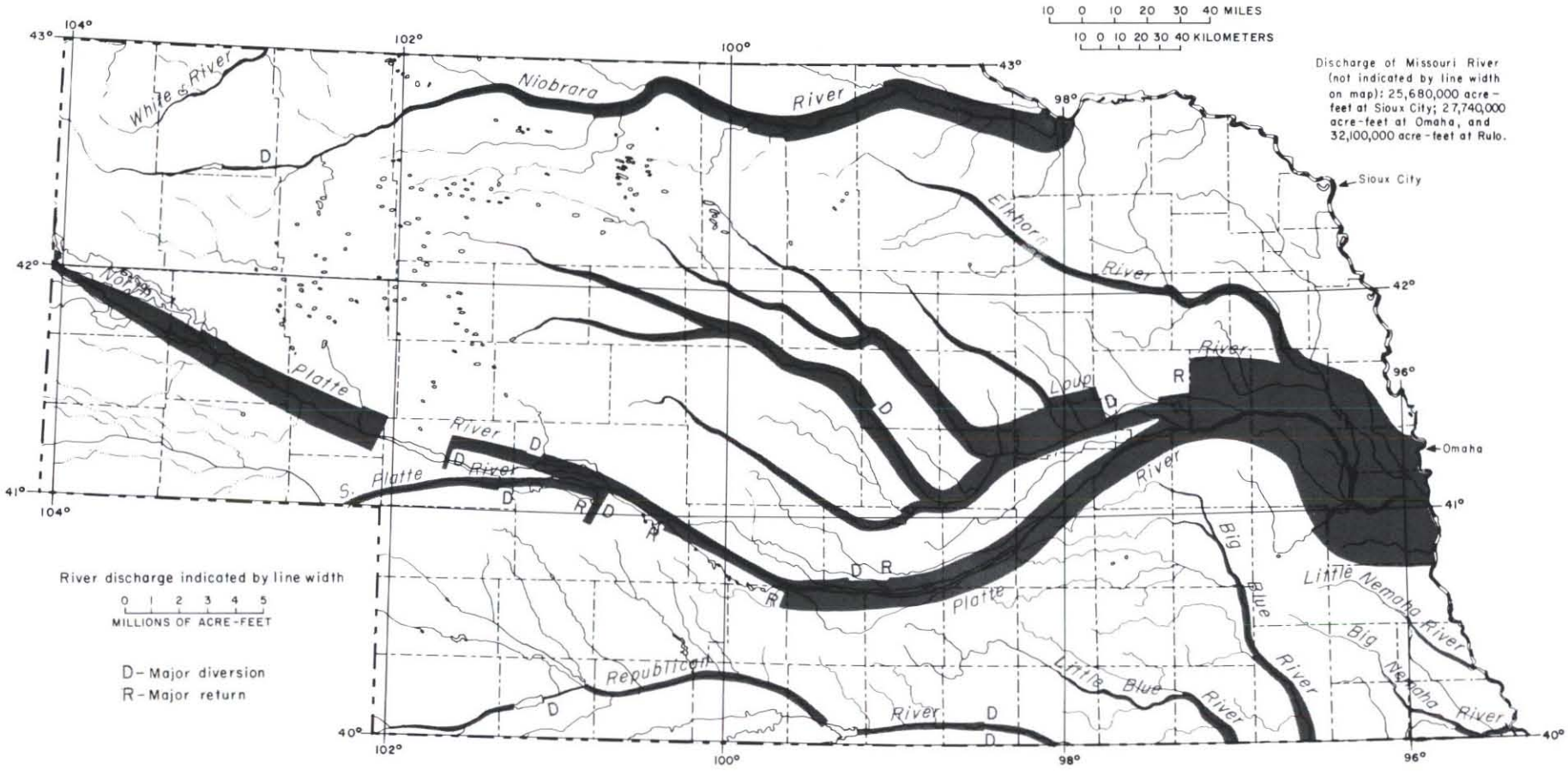
Surface water can be used in a variety of supplemental water projects. The water can be impounded at its source or in the area of its use or both. It can be diverted into various transfer systems. Surface water can be used to recharge groundwater reservoirs which are connected and adjacent to it. These uses can be met by both flowing and standing surface water. In Nebraska the surface water which is available for supplemental supply is found in the state's hundreds of miles of flowing streams, including the Missouri River.

Figure 3-1 shows by line width the discharge of Nebraska's principal rivers in water year 1975. In that year Nebraska received a little less water by inflow and precipitation than usual. The supply received was not as well distributed as in some years. Total outflow amounted to 6.7 million acre-feet. In Figure 3-1 abrupt decreases in line width indicate points of major diversions (D), and abrupt increases in line width indicate points of major returns (R) or tributary inflows. Complete breaks in lines represent onstream reservoirs.

By far the greatest part of streamflow leaving Nebraska is discharged directly into the Missouri River, which defines the state's east boundary. The remainder of the outflow is to South Dakota, Colorado, and Kansas. Despite the intensive use of water in the Platte River drainage basin, the Platte River's annual discharge to the Missouri during the decade preceding water year 1975 ranged from about 47 percent to 62 percent and averaged about 55 percent of the total outflow from the state. The Niobrara River, which also discharges into the Missouri, produced from 8 to 19 percent and averaged about 14 percent of the total outflow during the same decade. In water year 1975, the contributions of these two rivers to the flow of the Missouri were about 51 and 14 percent, respectively, of the total outflow from Nebraska. The Republican, Little Blue, Big Blue, and Big Nemaha rivers together produced about 20 percent of the state's outflow in the same year. The greatest potential for supplemental supply may be the Missouri River which annually discharges at Sioux City, Iowa, over 25 million acre-feet, four times the state's outflow (Bentall and Shaffer, 1979).

Figure 3-1 graphically depicts the surface-water discharges and their sizes in Nebraska. However, this figure must be used with caution in assessing amounts of surface water that might be available for supplemental use. Much more detailed analysis of several factors is required before reliable supplies of available supplemental water can be determined. Examples include the North Platte, Loup, and Republican drainage basins. The discharges that are shown on the map for these basins already may be appropriated to lower reaches of the basins or adjacent lower basins. Appendix A, "Water Supplies in Nebraska Streams," presents

FIGURE 3-1
DISCHARGE OF THE PRINICIPAL RIVERS, WATER YEAR 1975



greater detail on water yield in each basin. It summarizes flows by basin for the ten-year period of 1969-78 (it is recognized that this may not be an adequate period to portray every stream). The flows are presented for tributaries and main-stem reaches in the basins. Diagrams of appropriations, diversions, consumptive use and flows for the Loup, North Platte, South Platte, Platte, and Republican drainage basins are also in Appendix A. Another approach to assessing unused water in Nebraska's streams can be found in *The Framework Study* (Nebraska Soil and Water Conservation Commission, 1971). Both approaches make it clear that the state has surface flows at certain points in streams which could be used for supplemental water development. The fact that close to half of this flow originates in the generally lower elevation eastern third of the state and that areas with higher economic potential generally occur in upstream areas to the west presents definite economic, technologic, and environmental constraints to its use. Use of these flows may require structures and transmission systems that are constrained for a variety of factors not the least of which might be economic. However, the supply does exist.

Water in a stream at any given time is from: (1) overland runoff (flow derived from rain or snow melt after precipitation or melt events); (2) reservoir releases; (3) return flow from irrigated lands or from municipal systems; (4) water moving from the groundwater reservoir to the stream (base flow); or from some combination of these sources (Bentall and Shaffer, 1979). Most perennial streams in Nebraska are natural groundwater drains and those streams or specific reaches of streams are described as gaining streams or reaches. Other streams, or most commonly certain reaches of streams, are described as losing, i.e., streamflow moves from the stream to the groundwater reservoir or is lost to evaporation or plant transpiration. For any given short period of time, some reaches of some streams can either be gaining or losing. Figure 3-2 identifies reaches of streams that, on an annual basis, generally lose water. These reaches may themselves include gaining and losing stretches. Losses, as described above, from the Platte River from south of Grand Island to the mouth of the Loup River are generally balanced by gains to the stream in the same reach (Bentall, 1980).

In some circumstances flowing streams can naturally recharge the groundwater reservoir adjacent to them and hence can supplement the recharge that comes from precipitation. Water added to a stream by diversion from another surface or a groundwater source or released from a surface reservoir also can supplement groundwater storage.

Surface water stored and spread for the purpose of irrigation has increased groundwater in storage in the irrigated areas and has provided the additional benefit of smaller but more uniform streamflows downstream from the developments. Such a benefit can be considered a bonus to water management in Nebraska. Purposeful attempts to store and spread or release surface water for groundwater recharge would provide a similar bonus.

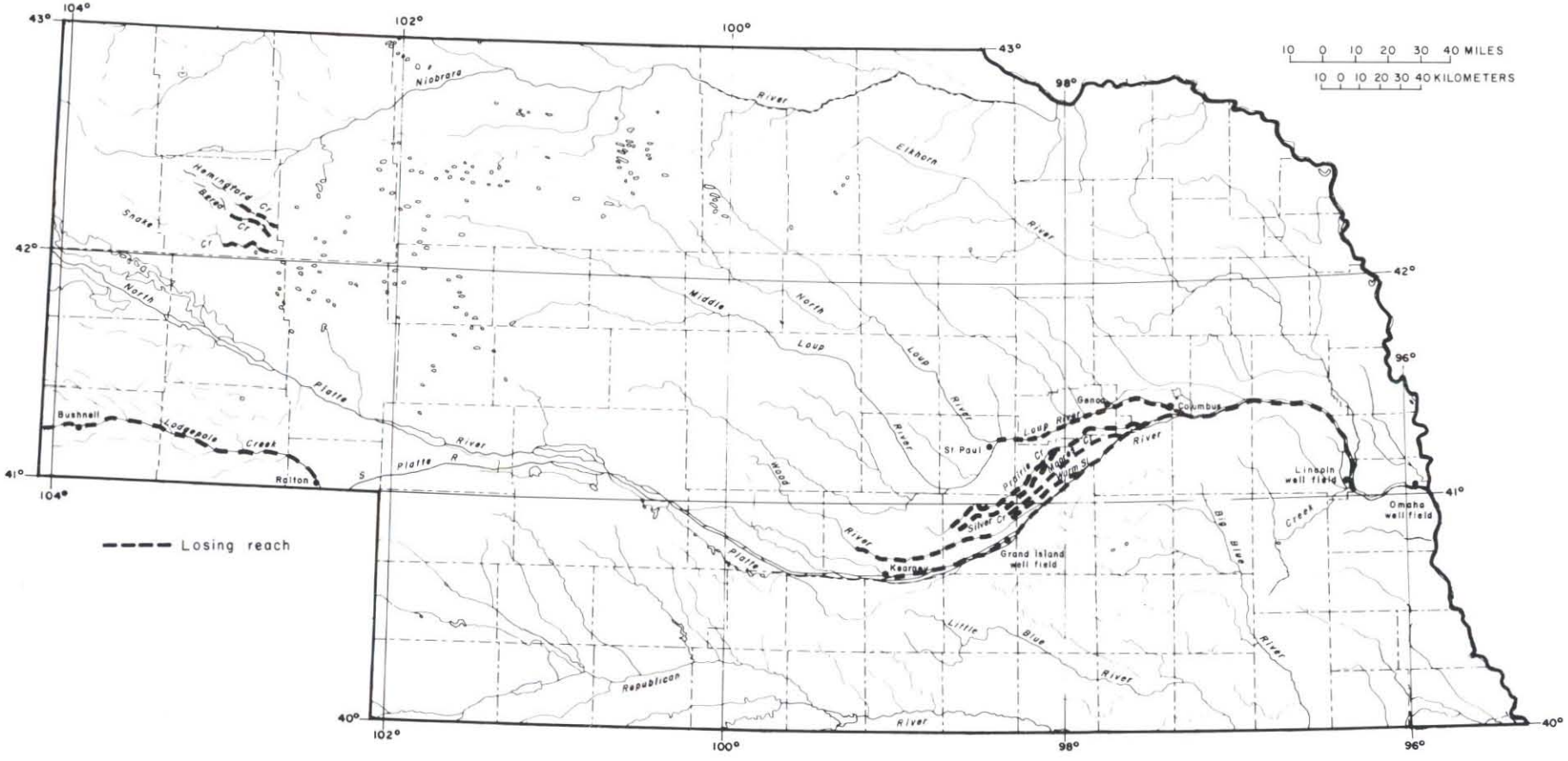
Overland runoff is the principal component of streamflow that can furnish supplemental surface water supplies in most Nebraska stream basins. Major streams in the sandhills portion of the state receive only minor amounts of overland runoff, so in this area such runoff cannot be viewed as a supplemental source of supply.

2. GROUNDWATER

Figure 2-5, groundwater in storage in the principal groundwater reservoir, demonstrates clearly that most of the state is well endowed with groundwater. It has been estimated that the shallow, permeable rocks in Nebraska contain more than two billion acre-feet of groundwater. Much of this water can be and is being used by installing wells. Figure 3-3 shows general areas of the state which have experienced significant water-level rises above the predevelopment water level. These rises have been caused by seepage from surface-water developments (reservoirs, transmission systems and application of water to land). This mounding of water presents a potential source of supply from groundwater.

Figures 3-4 and 3-5 can be used with some areas excepted to determine where Nebraska's groundwater supplies might be tapped for supplemental uses. They show areas where groundwater in storage would appear to exceed use-demands over any foreseeable period. These areas were identified by the following procedures. For each township, the quantity of groundwater (see Figure 2-5) was compared to the maximum irrigation development based upon land capability from Figure 2-4. A series of these comparisons was

FIGURE 3-2
LOSING REACHES OF STREAMS



generated by varying the consumptive use per well equivalent (160 acres irrigated). It was assumed, for maximum stress, that these well equivalents were installed all at one time rather than progressively developed.

Figure 3-4 illustrates those townships where the current amount of groundwater in storage exceeds the 200-year demand at a consumptive use rate of 150 acre-feet/year with historic irrigation practices and maximum development. The 200-year projection is assumed to exceed the time-frame for any anticipated management strategy. For significant areas of Nebraska such maximum utilization would not cause severe depletion within this time frame. Figure 3-5 illustrates the effects of a 90 acre-feet/year rate of consumptive use per well equivalent. This implies the implementation of more efficient and inovative irrigation techniques which would expand the area of 200-year aquifer capability.

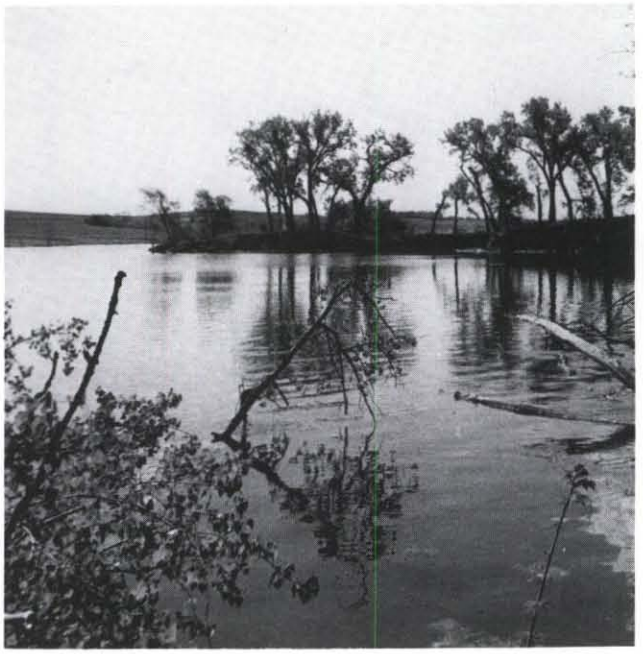
A comparison of these two figures (3-4 and 3-5) with Figure 2-5 (groundwater in storage) will identify areas in the state where groundwater could be available for supplemental water supply. The exceptions would be areas in northern Sioux and Dawes counties where the aquifer is very thin or absent. This discussion considers only quantity of groundwater and does not take into account effects on the entire hydrologic system. The method employed does show where the large reservoirs of groundwater are available.

B. TRANSFER

The key to a supplemental water project, by basic definition, is the capability to transfer water from its source of supply to its area of use. Transfer systems included in the scope of this study are pumps, canals, pipelines, streams, and methods of groundwater-reservoir recharge. All these systems are feasible in Nebraska. The state has numerous supplemental water-movement systems constructed to meet various needs. They range from small reclamation projects and direct stream diversions for small canal systems to the complex systems of the Tri-County Project (Hamaker, 1964) and the Loup Power Project. The drainage basins of the Niobrara, Loup, Plattes, and Republican have a variety of transfer developments. Appendix A presents some information on them. To date these developments have been designed to transfer surface water by gravity from a storage or diversion site to another area of surface-water use. This type of transfer may be limited in the future because most of the available streamflow is in the subhumid eastern part of the state which is considerably lower in elevation than the drier, more needy areas of the central and western portions of Nebraska. Transfer systems of the future in Nebraska may look to movement of groundwater from the north central area of the state (Figures 3-4 and 3-5). Transfers from either source may require lifting and thus be subject to energy and economic constraints. Technological constraints to transfers are discussed in Chapter 4, Section B of this report.

C. STORAGE

An essential component in many supplemental water systems is the capability to store water at its source or its area of use. This section examines the potential



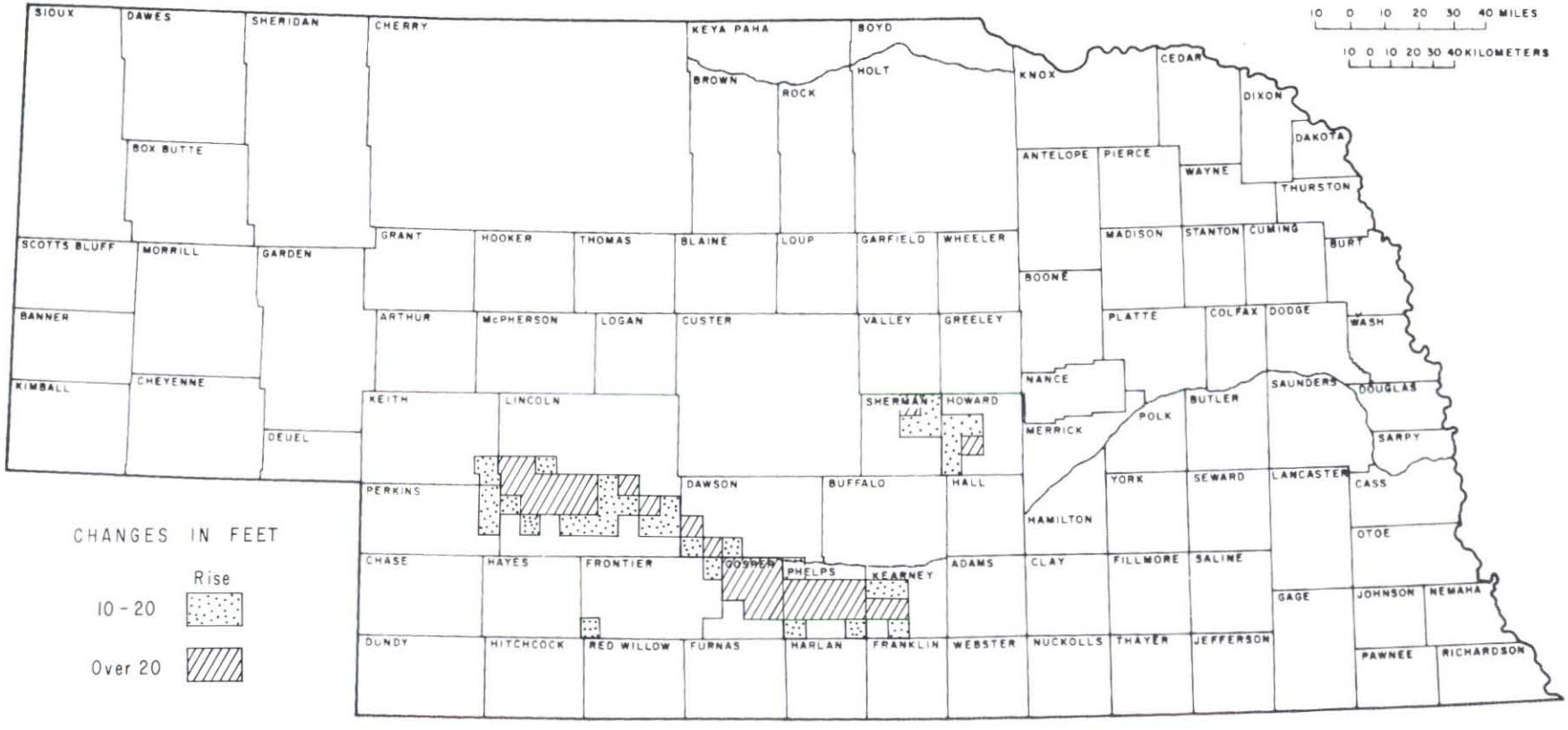
for surface and underground storage of water in Nebraska.

1. SURFACE

At an early stage in this study consideration was given to developing a map showing all potential surface sites for water storage in the state. It was soon determined that at best this would result in a shaded topography map. Geological and soil constraints could not be included for reasons of time and money. Thus, such a map would be of almost no value. The second approach was to develop an inventory of surface-storage sites that had been studied in the past forty years in Nebraska. A size limitation for sites was set at a minimum of 1,000 acre-feet normal storage. This size was selected to keep the final map readable and because this amount of storage is close to a minimal size for a supplemental water system, as defined in this study, which could be used for purposes of project-size irrigation. As the inventory was developed it was decided to also show existing facilities which meet the above same criteria.

Figure 3-6 is the result of this inventory and shows a total of 272 sites. This includes 59 existing facilities and 213 locations which have been studied. Some sites have previously been rejected. Appendix B provides a brief description of each site in tabular form which in-

FIGURE 3-3
TOWNSHIPS WITH SIGNIFICANT WATER LEVEL RISES SINCE PREDEVELOPMENT



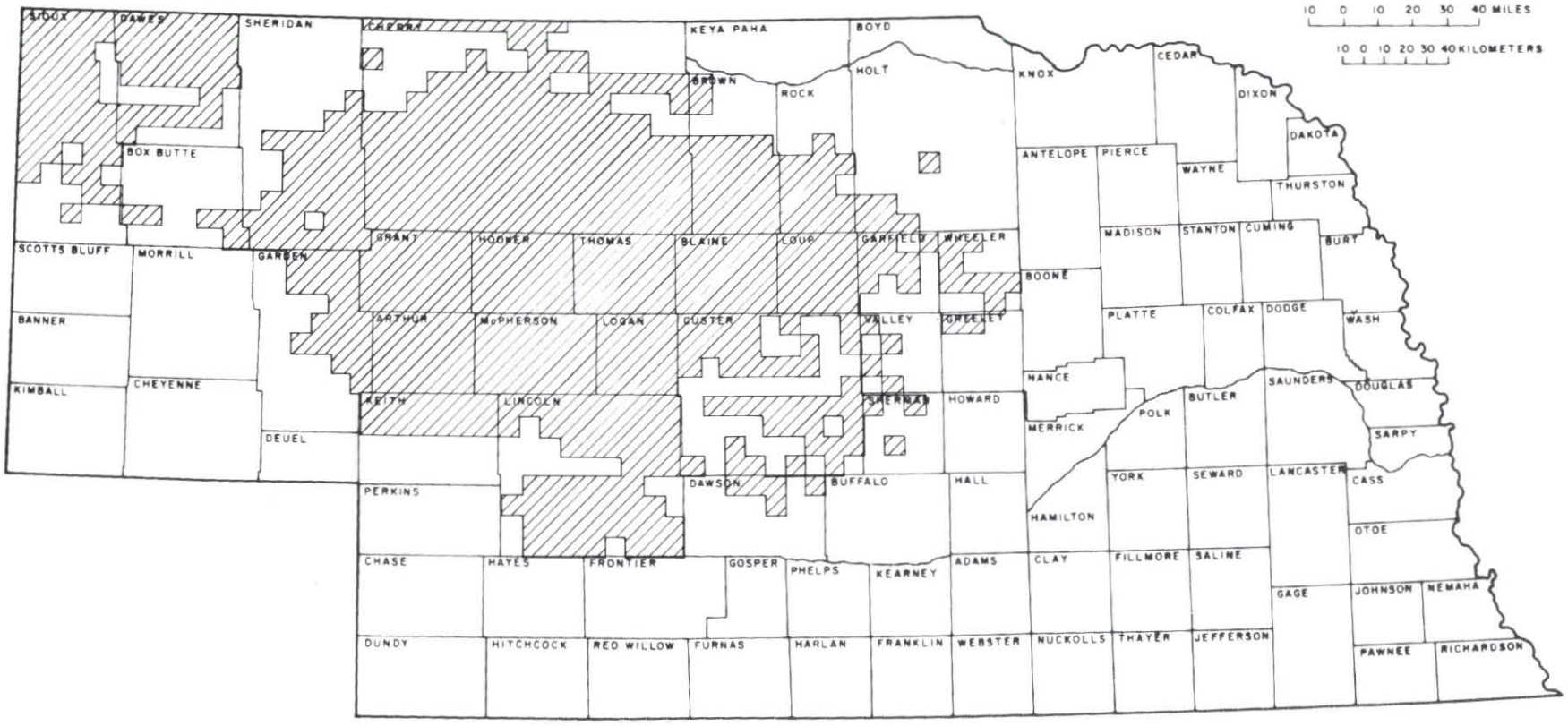
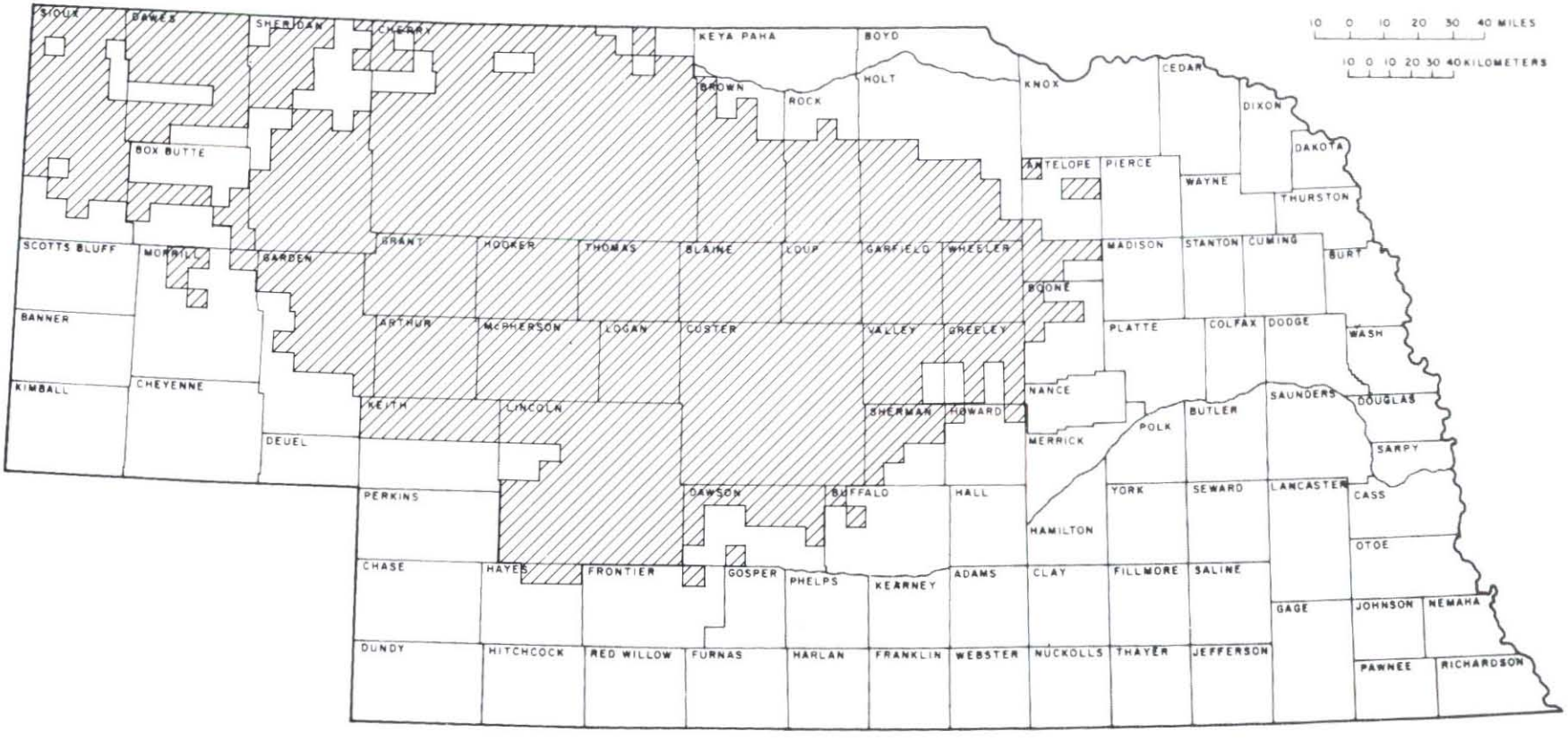


FIGURE 3-4

TOWNSHIPS WHERE GROUNDWATER IN STORAGE EXCEEDS 200-YEAR REQUIREMENT OF MAXIMUM PROJECTED IRRIGATION DEVELOPMENT (DEMAND RATE EQUALS 150 ACRE FEET/YEAR PER WELL EQUIVALENT)

FIGURE 3-5

TOWNSHIPS WHERE GROUNDWATER IN STORAGE EXCEEDS 200-YEAR REQUIREMENTS OF MAXIMUM PROJECTED IRRIGATION DEVELOPMENT (DEMAND RATE EQUALS 90 ACRE FEET/YEAR PER WELL EQUIVALENT)



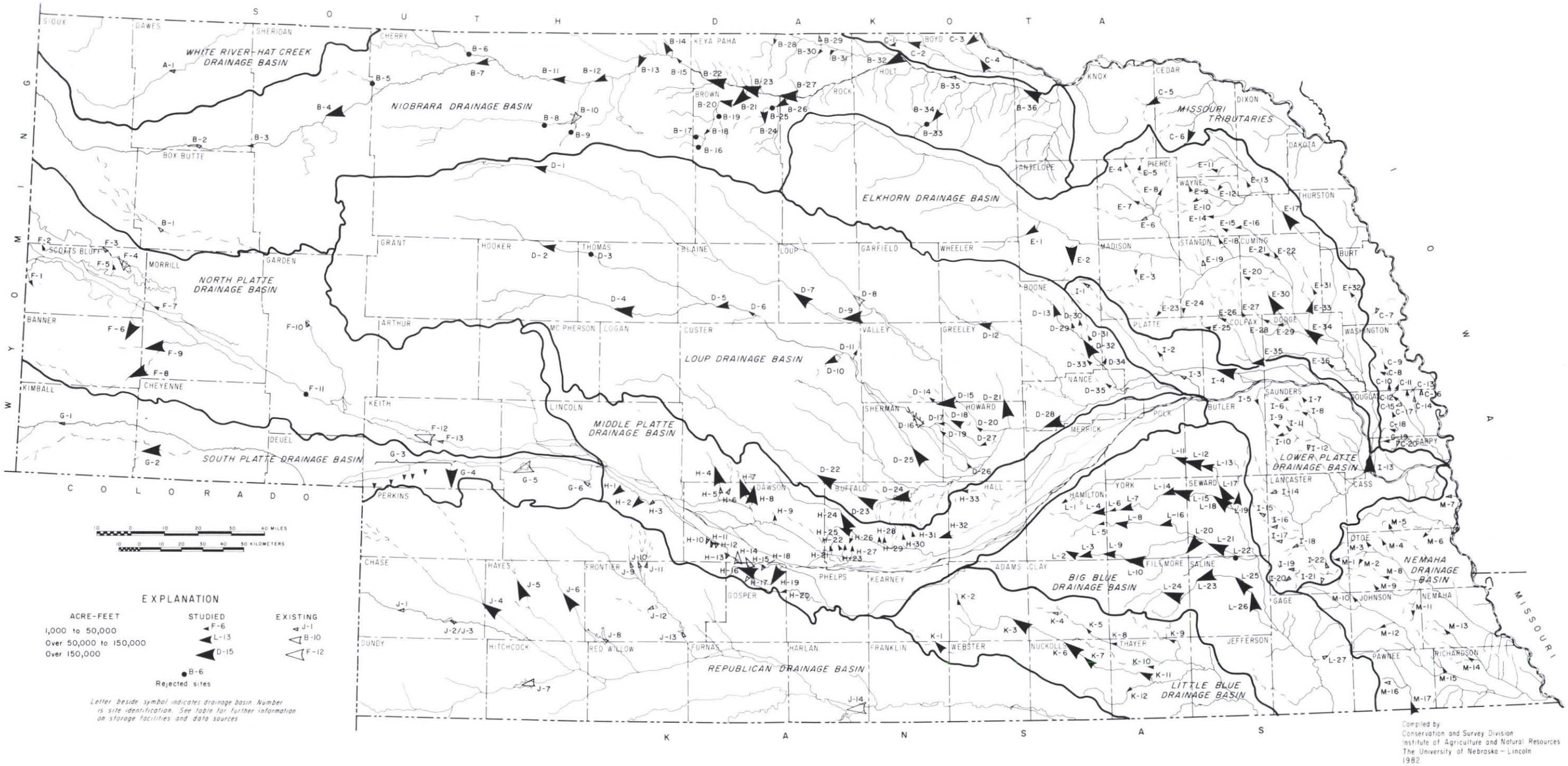


FIGURE 3-6

PROPOSED SITES AND EXISTING FACILITIES FOR STORAGE OF 1,000 ACRE-FEET OR MORE IN NEBRASKA

cludes a site name, stream location, county location, normal storage capacity and proposing agency. Included notes indicate features such as requirements for off-stream supply and stage of development. From Figure 3-6, it is apparent that numerous on-stream and off-stream sites might be available for storage. The majority of existing facilities with a capacity of over 50 thousand acre-feet are located in the western half of the state. Proposed sites of similar size are distributed throughout the state. Many of these sites will require a water supply in addition to that available in the local drainage area. In some cases, a technically sophisticated transfer system might be needed for the supply.

In summary, there is a physical potential for the development of additional surface storage for supplemental water systems in Nebraska. Such new systems as well as some existing systems will require the exercise of new technologies, growth in knowledge and additional funding and institutional arrangements. Perhaps the greatest opportunity and challenge lies in integrating new surface water storage facilities with groundwater-storage reservoirs; managing the supplemental water which would be provided presents an equal challenge and opportunity. However, it should once again be remembered that all of these physical potentials are subject to economic, environmental and other constraints.

2. UNDERGROUND

The potential for underground storage of water exists in many locations in Nebraska. Such storage has been planned and tried in only a few locations and on a small scale in Nebraska. Thus far, these experiments have demonstrated technical feasibility (Lichtler, Stannard and Kouma, 1980). Unintentional storage which caused water-level rises has occurred in several locations as a result of surface reservoirs and transfer systems (Figure 3-3). There have been few attempts to utilize this "incidental storage" although irrigation wells that do take advantage of the situation have been installed.

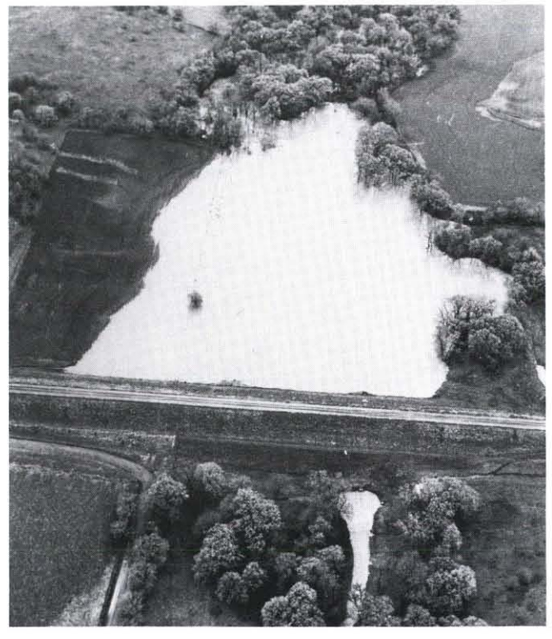
Underground storage is dependent upon many factors. One important factor is the capability of the rocks to accept, hold, and release water. Figure 3-7 delineates the underground water areas in Nebraska. All regions except for 10, 11, 12, 13 and the southern part of 9 have subsurface materials that are generally suited to holding and releasing water.

Figures 3-8, 3-9, and 3-10 give further indications of the potential for underground water storage.

Figure 3-8 is a depth-to-water map indicating the total thickness of sediments that lay above the top of the saturated zone in the spring of 1979. This thickness includes both fine-grained sediments, with limited storage potential, and coarse-grained sediments. Generally speaking areas near streams and in flood plains have high water levels and thus only have limited potential for storage of water. The topography of the Sandhills area of the state is typified by alternating dunes, some up to several hundred feet high, and interdunal valleys. No attempt has been made to map the contour depth to water in this area of highly variable topography.

Figure 3-9 shows total thickness of unsaturated sand, sand and gravel, gravel and sandstone. Thick sequences of silty sand to sandy silt are not included but one-half the total thickness of thin layers are included. The map presents predevelopment conditions. The limited number of control points in the topographically variable Sandhills area precludes precise and detailed delineation of the conditions there. One must view this map with caution when considering recharge potential, because no consideration has been given to the effect of local topography on drainage that might occur if these sediments were recharged. Those areas where water levels have declined from equilibrium conditions would be effective for storage of recharge.

Figure 3-10 is a Fall, 1981, map of townships containing areas of significant water-level declines and rises from predevelopment conditions. The map indicates the amount of previously unsaturated material that has become saturated because of storage reservoirs, canals, and irrigation practices. This space is now unavailable to recharge. The map also demonstrates that storing water in subsurface materials is feasible in selected areas. The map furthermore indicates the amount of previously saturated material, both fine and coarse, that is now available for storing water. This space was not available under predevelopment conditions. Full utilization of the groundwater reservoirs for storage, in conjunction with the total water supply, may require drawing down the water level of the reservoirs.



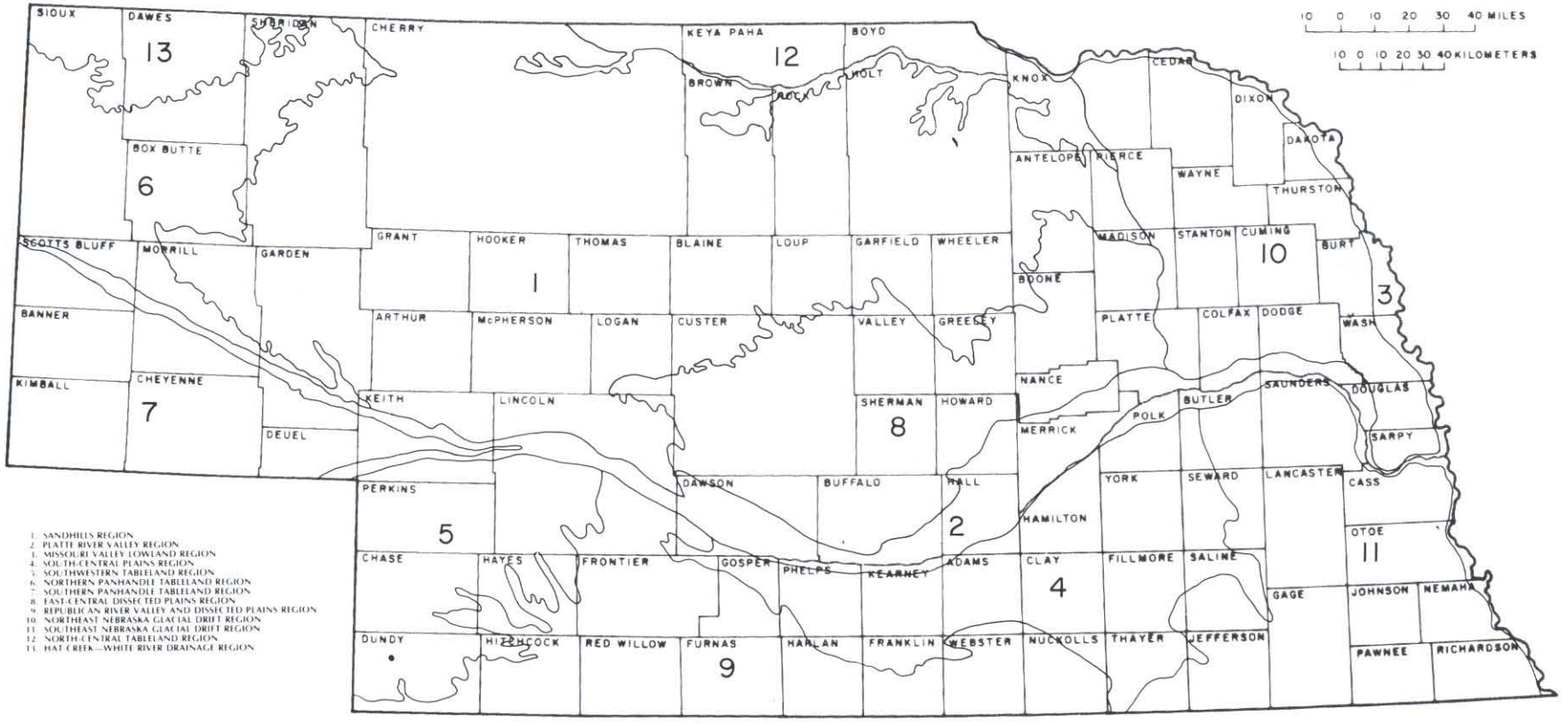
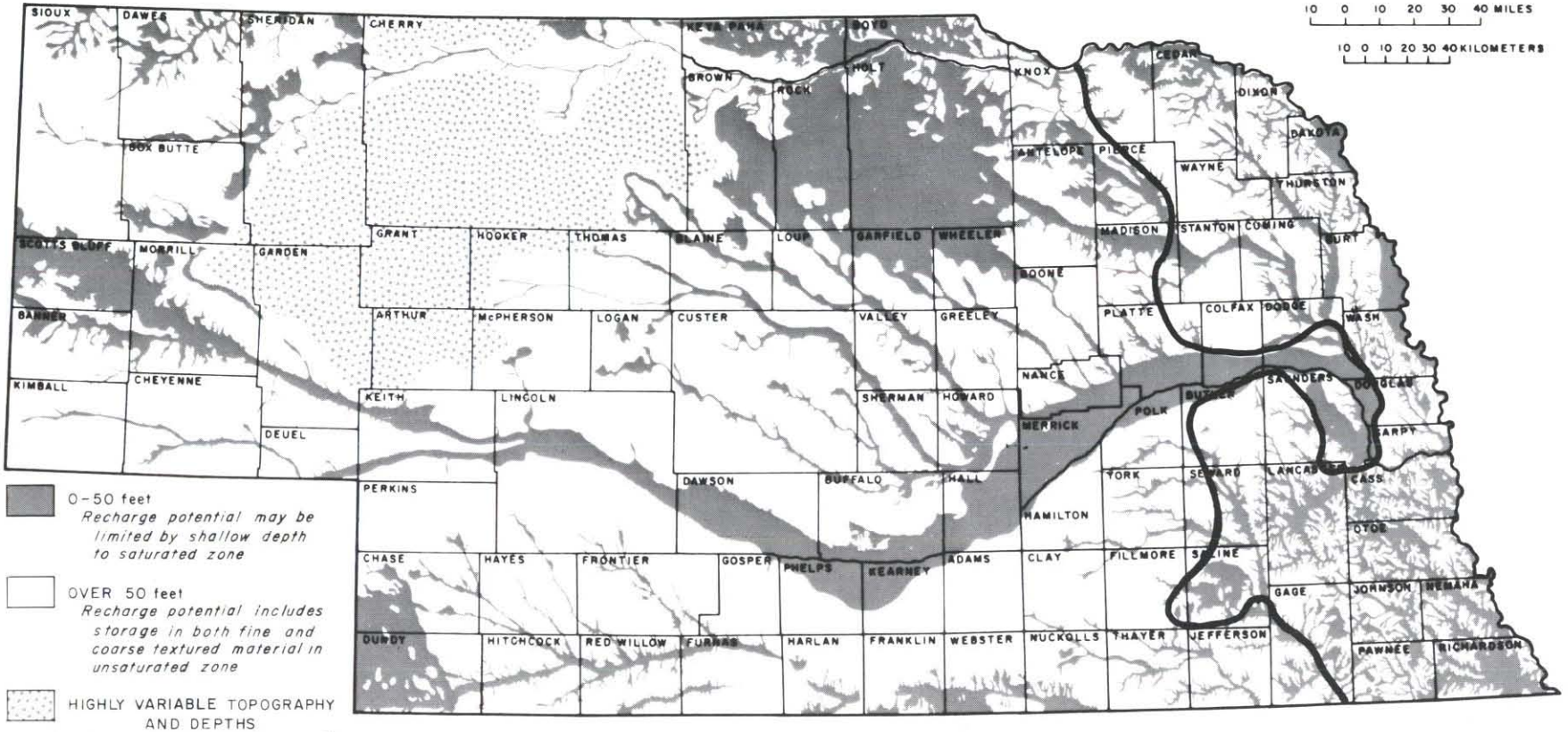


FIGURE 3-7

UNDERGROUND WATER AREAS

FIGURE 3-8

GENERALIZED DEPTH TO WATER



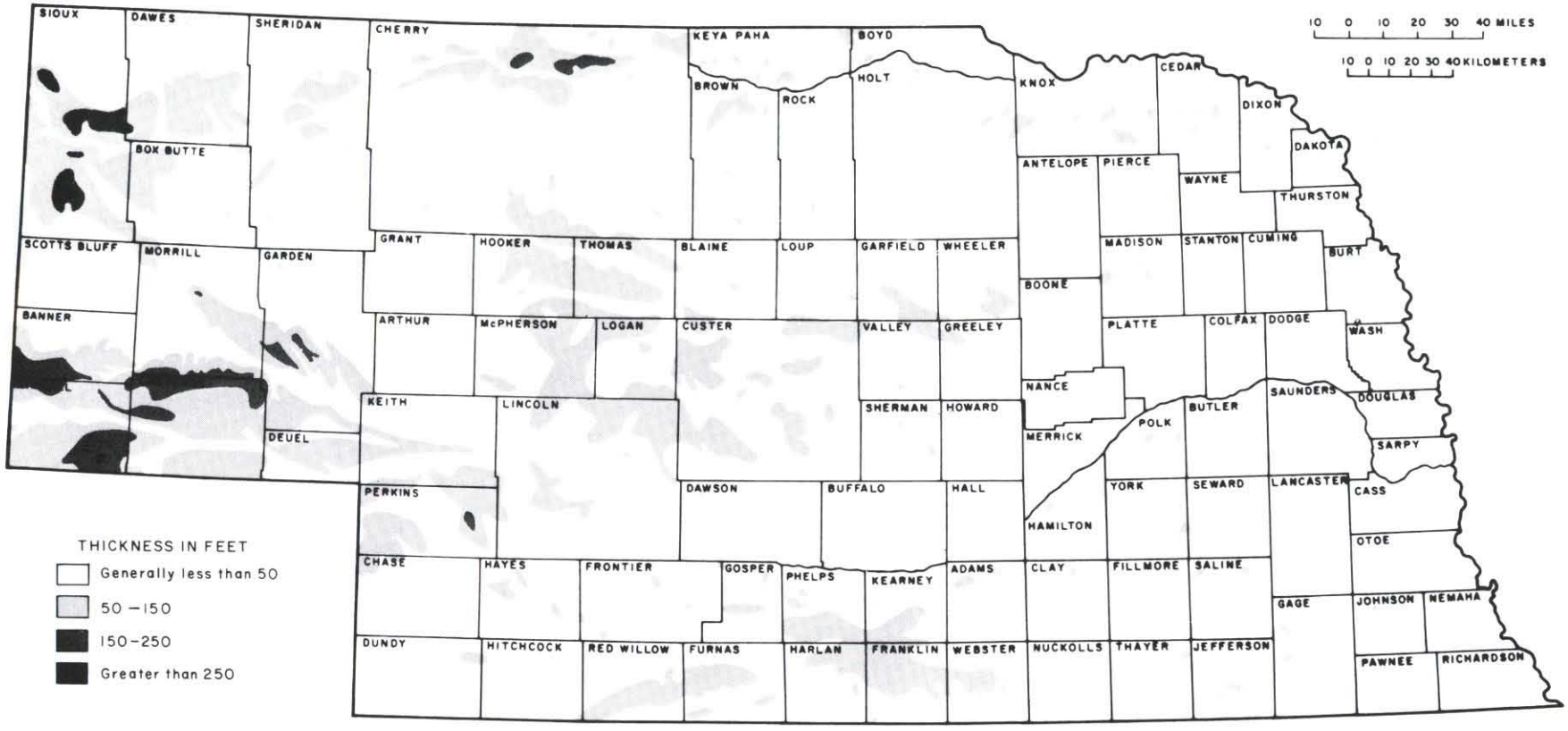
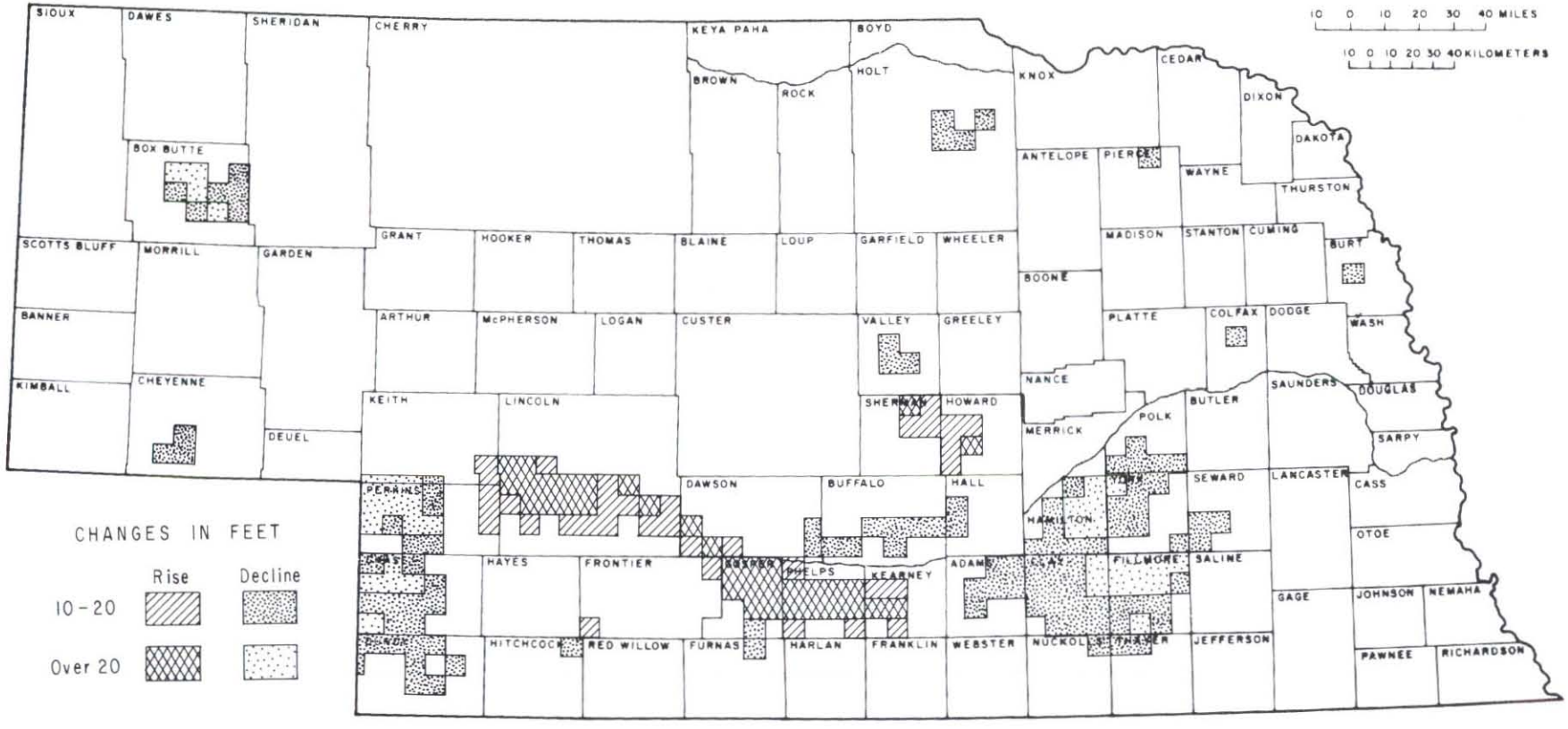


FIGURE 3-9

THICKNESS OF UNSATURATED COARSE MATERIALS, PREDEVELOPMENT CONDITIONS

FIGURE 3-10
TOWNSHIPS CONTAINING AREAS OF SIGNIFICANT WATER LEVEL CHANGES SINCE PREDEVELOPMENT



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Chapter 4

Impacts and Constraints

Every supplemental water development can impact on and be impacted by naturally occurring and culturally created conditions and factors. In either circumstance when the impact is proven, or is perceived to be a hindrance to development then the impact is considered a constraint. This chapter presents a possible range of such impacts under six section headings — environmental, technological, social, legal, institutional, and economic. Each section includes an assessment of those impacts which could be considered constraints to the development of supplemental water projects in Nebraska. The impacts are presented here as general in contrast to the more specific impacts of alternatives which will be found in Chapter 5.

A. ENVIRONMENTAL

A major task in the development of supplemental water projects is identifying environmental impacts related to a project and determining if the impacts are constraints to the proposed development. This task is difficult for two reasons: (1) the parameters for environmental impacts are vast, and (2) the interpretation of these constraints is limited by a lack of data and is open to argument by experts. The difficulty increases when a study such as this one is general, state-wide and non-site specific.

For this study a broad list of environmental impacts was developed. Then respondents, familiar with water-supply development and its evaluation, were invited to assess the positive and negative nature of these impacts. Negative impacts can be considered potential constraints. This assessment was done through three rounds of surveys using the Delphi technique. A complete report on the methodology of this assessment is found in Appendix C to this report.

What follows is a summary of the complete report which includes an outline of impacts considered and a generalization of constraints identified by survey respondents. Appendix C presents significant aspects of the assessment which cannot be fully synthesized in this summary. The summary is in four subsections: (1) sources of supply, (2) transfer, (3) storage and use, and (4) concluding remarks.

1. SOURCES OF SUPPLY

a. Impacts Considered

Surface water as source of supply

Impacts of impoundments

water quantity: increased evaporation; change in water levels in impoundment based on management and hydrologic impact on aquifers due to storage and possible recharge through seepage.

water quality: possible increases in total dissolved solids, sedimentation and eutrophication; change in water temperature; possible stratification in impoundments; possible reduction in turbidity in impoundments and mixing of water temperatures above dams.

soils: possible increase in erosion along shorelines of impoundments.

vegetation/habitat/fish and wildlife populations: (1) aquatic: change from shallow, flowing habitat to deep, still habitat; change in type of fish populations - species composition - biomass changes; change in movement of fish populations; change to silt and mud bottom community; change in emergent and submergent vegetation and related invertebrates and fish and change in value of shallow areas of impoundment due to fluctuations, possible sterile littoral zone and reduced value for waterfowl and other wildlife. (2) terrestrial: inundation of riparian habitat with subsequent loss of related functions as wintering area for deer, furbearer habitat and area of high density of wildlife; loss of some populations and dislocation of others; change in

migration of wildlife and shift from terrestrial ecosystem to aquatic.

land use: increased public access; recreational use of impoundment and shoreline; related requirements for infrastructure, waste disposal, etc. and secondary impacts of increased land development along shoreline or in area.

aesthetic/visual: change from flowing stream and riparian environment to open water and probably open shoreline and possible loss of woodland environment depending on site.

Impacts of diversions and downstream effects of impoundments

water supply: change in downstream flows - generally reductions, but with possible changes or increases depending on management and releases (peak flows may be reduced and minimum flows increased).

water quality: change in relation to flow; generally declines with reduced flows and sediment may be trapped upstream, but loading will vary with flow and management of impoundment.

vegetation/habitat/fish and wildlife populations: change in area of floodplain; change in riparian and aquatic vegetation, habitat and related fish and wildlife populations (degree will depend on change and variation of streamflow); change in water temperature may affect fish populations and possible change in fish movement and spawning.

land use: possible change in recreation or other use due to reduced flow.

aesthetic/visual: change related to impact of reduced flow.

Groundwater as source of supply

Impacts of withdrawals of groundwater

water supply: (1) groundwater: reduction in water levels and wetland areas. (2) surface water: reduction in streamflow in some areas and in some lakes and impoundments.

vegetation/habitat/wildlife populations: changes as related to changes in streamflows or wetlands.

land use: changes as related to the above effects.

b. Constraints identified

The possible effects of the development of impoundments in areas of the source of surface-water supply (presumably flowing streams) was illustrated by varying assessments among survey respondents of what was a "positive" impact and what was a "negative" impact. Varying estimates were made of the influence of eventual management practices on impacts. In some cases the estimation was that either positive or negative effects could take place depending on location and other factors. Uncertainty in predicting general outcomes may have also influenced the responses. Different perspectives toward the systems at work (biological and hydrologic) may have been a factor as well. Changes in habitat appeared to elicit disagreement as to the significance of their impact. On some items responses were spread across positive and negative scores. On other items a substantial percent estimated "no significant impact" while significant percentages of respondents estimated either positive or negative impacts. Development, use and accessibility were seen as positive as were some habitat changes and hydrologic impact on groundwater reservoirs.

Impacts of surface-water diversions and downstream effects of impoundments were assessed by the survey respondents. The downstream effects illustrated some disagreement among respondents as to the extent of impact of particular changes. The most significant positive assessment was one which dealt with change in the vegetation and habitat of the floodplain. Both positive and negative responses were given to the effects of trapping sediment upstream. Change in recreation and effects of change in water temperature also resulted in divided responses. Effects on streamflow itself, water quality and visual quality were given moderately negative assessments. Overall, any potential constraints were moderated by the possible variability in outcome, the perception of a lack of dramatic potential changes due to few cold-water streams, the significant influences of management of flows, and simultaneous positive and negative effects.

The use of groundwater as a source of supplemental water suggested a fairly limited list of environmental impacts. The survey responses all indicated a negative potential for all of these impacts. They seemed to reflect a consensus and more uniform perception about the possible effects of major change related to reductions in groundwater supply. Groundwater was not perceived as being used to any great extent as a source of supplemental water in Nebraska. The perceptions which were evident in the survey apparently were gained from groundwater reductions which result from current uses of this source of water.

2. TRANSFER

a. Impacts considered

Canals as method of transfer

Water supply:

groundwater: change if seepage from unlined canals.

surface water: change in flow, if existing canal.

Water quality: change if mixing of water occurs (new and previous flow).

Fish and wildlife: loss of fish populations at intakes to canals in some locations and barrier and hazard to wildlife.

Land use: interference with access, farming and other activities and safety hazard.

Pipelines as a method of transfer

Habitat, land use: some disruption of activities during construction and along corridor; possible loss of habitat; possible disruption of migration or movement of wildlife populations and probable change in species composition of vegetation.

Existing streams as a method of transfer

Water supply: increase in flow with possible variations from management of supply.

Water quality: change in temperature and possible change in chemical and biological parameters as mixing of water occurs and possible change in sedimentation.

Soil: possible increase in erosion due to increased bank erosion.

Vegetation/habitat/fish and wildlife: possible change as related to streamflow and water-quality factors.

Induced recharge into groundwater reservoirs as a method of transfer

Water supply: increase in groundwater level and possible reduction in streamflow if streams are a losing source.

b. Constraints identified

Generally, increases in groundwater supplies from leaky canal seepage or induced recharge were estimated by survey respondents as positive effects. Disruptions in human activities, dividing farms, loss of fish and increased hazard for wildlife were seen as negative in relation to canals. Other biological effects of canals were viewed as not having significant effect, although with some uncertainty and a share of negative rankings. Pipelines were estimated as more moderate in their effects, but with a share of negative rankings. Use of existing streams elicited positive estimations as to increased flow, negative in relation to possible increased erosion and no significant impact on several items related to water temperature, quality and vegetation. Overall, activities leading to increases in supply or flow of water or related human activity were often assessed as positive in their effect.

3. STORAGE AND USE

a. Impacts considered

Storage of water on the surface

Impacts of on-channel impoundments were the same as previously rated for surface water impoundments under sources of supply.

Additional changes resulting from mixing of new and existing water supplies: water quality effects including temperature, concentrations of chemicals, biological parameters, sediment and other factors.

Impacts of off-channel impoundments: change in habitat from terestrial to aquatic and possible wide variation in water level due to management effect on shoreline zone and general area.

Storage of water underground

By spreading of new water through canals, reservoirs, etc.

water supply: change in groundwater reservoir storage subject to infiltration and percolation rates and characteristics; possible waterlogging of lands; increase in evaporation and geologic impacts in general.

water quality: change in temperature; physical and chemical quality of water; sedimentation possible if surface-water source and microbial growth possible if surface-water source.

soil/land use: waterlogging and possible treatment of sediment and microbial growth to maintain infiltration.

By injection wells

water supply: change in groundwater-reservoir storage.

water quality: compatability of new water with existing supply; dilution of existing supply with recharge water and impacts of surface-water sediment and microbial growth.

Impacts from use of supplemental water

Continuation, expansion or new development of irrigated agriculture.

Water supply: effect of use on surface water or groundwater supply in terms of rate and amount of seasonal or on-going use; impact on areas of high water table and wetlands and impact on streamflow from surface water or groundwater use.

Water quality: possible increase in nitrate concentrations due to increased irrigated agriculture and possible dilution of nitrate concentrations in existing groundwater supply subject to quality of imported water, or if surface water is used.

Soil: change in erosion from increased runoff due to increased use of water; reduced wind erosion due to irrigation; impacts from varying management practices and wind erosion of sandy soils in winter and early spring.

Vegetation/habitat/wildlife populations: changes in wetland areas, lakes and streamflow; development of new land; reduction in woodlands, mixed grassland and cropland and intensity of agricultural development.

Aesthetic and visual resources: new uses of land and their effects on water quantity and quality; landform modifications; agricultural practices and surface-water storage and related streamflow changes.

b. Constraints identifies

Survey responses generally assigned the impacts from on-channel and off-channel impoundment as not significant. Off-channel impoundments were seen to have impacts which included habitat change and water-level change. They were given negative ranking. These estimations appeared to reflect the basic change in use and natural systems where inundation takes place and the effects of necessary variation in water level.

Impacts were considered in the instances of storing water underground through spreading from canals, reservoirs, etc., or through injection wells. They reflect assessment of technologies which have only been used experimentally in Nebraska with respect to supplemental water-supply development. Many are closer to technological impacts than environmental impacts. The only impact assessed by survey respondents as positive was the change in groundwater-reservoir storage brought about by surface spreading. All other impacts were assessed as negative except for the change in water temperature and physical and chemical quality; impact of new water on existing supply-compatability and change in groundwater-reservoir storage characteristics. These had response of no significant impact although they also revealed both positive and negative assessments. These assessments may reflect concern for the quality of groundwater supplies combined with some uncertainty as to the positive and negative attributes of these activities; particularly in relation to chemical quality of water, operating costs in terms of displacement of land uses, evaporation and other concerns.

The uses of supplemental water also result in environmental impacts. However, these impacts are identical to those already considered in the supply, transfer, and storage of supplemental water. The assessments by survey respondents of the impacts also was generally the same. The exception is the impact of changes on the state's agriculture industry. This impact is discussed more appropriately in Sections C and F of this chapter.

4. CONCLUDING REMARKS

The preceding discussions represent attempts to evaluate the type of effect and degree of effect of a set of general categories of activities within the physical arena of the entire state of Nebraska. This effort was conducted within a communication process established around a pattern of interaction between respondents to surveys. There were likely some gaps in this communication reflected in problems of the design, or statement of some questions and the different perspectives of respondents. Yet some conclusions can be drawn from this process. First, there are genuinely differing perspectives as to the effects of surface-water development and storage in certain areas of impact. These reflect differing evaluation of the quality of habitat, of the management of surface-water supplies and of significant geographical differences and potentials. Second, there appears to be a closer consensus on the major impacts of reductions in groundwater supplies in the area of reduction. These effects are more clearly seen as negative. Third, modes of transport and programs of groundwater storage are seen as possibly negative in effect or problematic in some but not all of their aspects. These generalizations should not limit the necessary review of these impacts, item by item, as available in Appendix C. This appendix presents significant aspects of the assessment which cannot be fully synthesized in these general comments.

B. TECHNOLOGICAL

The following material generally outlines the technological constraints on development of water for supply augmentation. The definition which was used for a technological constraint is, "A physical limitation which either reduces the efficiency of a supply augmentation technique or which requires the use of additional inputs to achieve desired results." The information is presented in three subsections: (1) sources of supply, (2) transfer, and (3) storage and use.

1. SOURCES OF SUPPLY

A variety of technological conditions can serve as constraints on the impoundment of surface water for storage where recharge is not desired. Common constraints include sedimentation which reduces the life of the reservoir, evaporation, permeable soils which allow leakage, high nutrient content which contributes to algae growth, unstable subsurface conditions, topography that does not lend itself to storage sites, cultural features, fluctuations in water level due to management requirements and variable or undependable water supply. Many of these constraints can be mitigated through current technologies. However, mitigation of those which are a result of natural conditions such as sedimentation, subsurface conditions and permeable soils frequently may be done only at great costs. Other natural conditions such as evaporation cannot be mitigated. Diversions from natural-flowing streams using low dams and overflow weirs are subject to constraints from unreliable water supplies, flooding and high sediment content in the water.

Groundwater as a source of supplemental water is subject to some specific and unique technological constraints. If the groundwater is obtained by pumping, these constraints include depth to water, in both the predevelopment state and as a result of declining water tables through usage. Some chemical constituents of water — boron, selenium, uranium, nitrates, and other salts etc. — can be constraints in the use of groundwater as a supplemental source.

2. TRANSFER

Canals, pipelines, and pumping are subject to a range of constraints of a technical nature. Land topography and subsurface conditions can cause problems as to location and movement for gravity systems. The same conditions can be constraints for lift systems and can result in great energy and financial demands. Soils can allow unwanted leakage and can also contribute to sedimentation. Evaporation and phreatophytes can greatly constrain the efficiency of a canal systems. Cultural features can impose restrictions on all of these transfer methods. The efficient use of existing streams for transfer may be constrained by evaporation, certain geologic features and the carrying capacity of the stream.

3. STORAGE AND USE

Technological constraints for the storage of surface water in the area of use are the same as those discussed for its storage at the source. However, the techniques for storage of groundwater, generally through recharge of unsaturated materials, are subject to many specific technological constraints. Water-spreading may be constrained by impermeable soils, sedimentation, microbial growth, mounding and waterlogging, rough topography, incompatible recharge and natural waters and subsurface geological problems such as inadequate porosity, permeability and unsaturated thickness. Recharge (gravity) and injection (pumped) wells as a means of storing groundwater may face technical problems such as sedimentation, microbial growth, incompatible water and entrained air. Canals that leak can be a planned method to introduce storage of groundwater. Their use for this purpose can be constrained by sedimentation, impermeable soils, microbial growth, phreatophytes, evaporation and subsurface condition. Losing streams as a means of recharge can have these same constraints. Recharge wells in canals can be affected by the constraints which apply to both the type of well and canals. Surface reservoirs which are built to recharge groundwater reservoirs have the same constraints of any surface-water reservoir except that permable soils are necessary.

The efficient and effective use of supplemental water, as with the use of any water, can be constrained by loss of water to evaporation or transpiration from plant surfaces. Constraints which arise from application losses can be reduced by irrigation scheduling, low-pressure applications, etc.

C. SOCIAL

The following material outlines potential social constraints to the development of supplemental water supplies. It is presented in three subsections: (1) sources of supply, (2) transfer, and (3) storage and use. In each, social constraints are presented as related to land use, population, local economy and attitudes.

1. SOURCES OF SUPPLY

a. Surface water

A diverse range of social factors can serve as constraints to the development of surface water reservoirs. These could include:

Land Use: Inundation of agricultural land will

reduce agricultural-related output of the local economy. This, in turn, could result in reduced local demands for products such as seed, fertilizer, etc., relative to the amount of land taken out of production. Potential inundation of large areas of prime farmland could create significant social/political constraints on reservoir development. Changes in the type of fish or other wildlife populations in a reservoir or reach may affect the recreation potential of hunting, fishing, canoeing, etc. The change may be positive or negative depending upon the type of habitat created or destroyed by the project. In addition, variations in reservoir-water levels can adversely affect certain recreational uses at the impoundment. Reservoir construction may also reduce aesthetic/visual qualities of an area if unique natural features are inundated. However, some citizens may feel that an impoundment would enhance the area. Construction of recreational homes may also be viewed both as a plus and minus. Perceptions of reduced recreation opportunities could create social constraints for potential reservoir construction in a particular area. Reservoir construction may increase the demand for temporary housing during the construction period, and for residential/recreational housing after completion. Housing shortages could occur during construction, but surpluses could exist after reservoir completion. Some homes or entire towns may need to be removed from the inundated area of the reservoir. Strong opposition to the necessary removal of homes and businesses and the inundation of farms could create social constraints on reservoir development. This could be offset to some degree by higher relocation compensation. The demand for public services will undoubtedly increase during construction, and may also increase after completion due to maintenance requirements. The major effect could occur on schools due to an influx of the children of construction workers. Inundation of land may reduce the local tax base of an area, but spin-off development could help offset, at least in part, these losses. Also, payment in lieu of taxes often associated with reservoir development could help offset tax base reductions.

Population: Primary and short-term increase in population would probably occur during reservoir construction. Shoreline development could provide opportunities for increases in seasonal recreational populations from cabin and trailer development. However, seasonal residents would likely be in the area only during the summer months. This could lead to somewhat of a "boom/bust" cycle in terms of population growth in a reservoir area. Construction workers would likely be younger than the average population of the area, and would probably be more transient than local residents. Seasonal residents may vary greatly in age. Both these types of transients may be unwelcome and not integrated into community. Institutions such as schools and law enforcement may feel strains. These population changes may also adversely affect the community's infrastructure (utilities, streets, etc.).

Local Economy: Property near a reservoir would probably increase in value if sites were available for residential development or if irrigation capabilities were provided by the project. New jobs for local and outside residents would be provided by reservoir construction. However, these would be short-term opportunities and may not increase local business activity after construction is completed. In addition, the extent of local employment benefits will depend upon the relative mix between local and outside labor. If most construction jobs are held by workers from outside the area, local employment opportunities may not increase as much as if local workers were utilized by the project. However, "spin-off" employment may be available for local labor, although it may be short-term (i.e., limited to the duration of the construction period). Some employment losses could occur due to loss of productive land inundated by the reservoir.

Attitudes: Area residents may feel that reservoir construction would enhance their area due to the development of new water supplies and recreation opportunities. However, others may resent having "their water" taken from the area to benefit another area. Those forced to leave an inundated area may hold resentment toward the project and its local supporters. Attitudes toward the project may be closely related to individual economic gain or/and loss. The split between those who gain and those who lose could lead to intracommunity conflict. If public monies are used, the attitude of some people may be that tax monies should not be used for projects that only directly benefit what they perceive as a small number of people. Conflict over local water supplies could lead to new social/political organizations in an area and a decrease in community cohesiveness if residents become divided over important issues. On the other hand, cohesiveness and joint action may emerge if residents should unite to encourage or exploit new shoreline development opportunities. Outside groups may exert pressures or may assist local residents in organizing opposition to water projects. Funding for such opposition groups could come from other areas of the state and from other parts of the country. These pressures would probably occur prior to or during construction, and may be the primary social constraint placed upon a project. Local residents may feel little change in their quality of life if they continue to receive adequate supplies of water. However, living conditions may be negatively affected if existing water-based recreation, such as canoeing or fishing, is adversely affected, or if local conflict with the project becomes intense. In addition, some may be concerned about "outsiders" residing on lakeshore properties.

b. Groundwater

The development of supplemental water through well fields with groundwater as a source of supply could be subject to some of the following social constraints:

Land Use: Groundwater withdrawals for exportation would probably be limited to amounts that would not seriously affect irrigated agriculture on overlying land. Negative recreational opportunity effects might occur if streamflows, wet meadows, or natural lakes were affected. Hunting, fishing, aesthetics, and visual quality could also be negatively altered. Demands could increase for road repair, electrical transmission line construction, etc., due to pumping-plant construction and operation. Domestic and municipal wells could be adversely affected if water levels decline.

Population: No particular constraints from population impacts were identified. However, this could depend upon the extent of development.

Local Economy: Land values could decrease if groundwater exportation negatively affected the productivity of land in the area. This might result in legal action on the part of landowners who were negatively affected and not compensated. No particular employment changes or constraints were identified. However, some employment benefits would occur as the result of well and transport-system construction.

Attitudes: Residents may feel increased concern about changes in the availability of groundwater in their area. Resentment will occur if water-table declines are such that redrilling of existing, previously productive wells is necessary. Community conflict could create a lack of cohesiveness among residents. New social/political groups may form if local leaders wish to protest or encourage existing political decisions regarding a proposed development. If local groundwater declines are perceived to be due to development decisions from outside the area, the threat of water shortages could serve as a rallying point, i.e., outside threats can increase community cohesiveness. The effect of groundwater exportation on perceived quality of life could be negative if adverse environmental changes are projected and not mitigated. If public monies are used the question of equity of benefits may help determine attitudes towards the project. The attitude of some people may be that tax monies should not be used for projects which they perceive as only benefitting a small number of people. However, those who financially benefit from the project might feel an improved quality of life.

2. TRANSFER

The following social constraints are possible as a result of methods of supplemental water transfer.

Land Use: Some loss of farm land may occur due to canal construction. Agricultural production could be reduced if significant amounts of productive properties were utilized for transport rights-of-way. The transfer system could also divide properties under single ownership. The potential would exist to create new recreation opportunities for canoeing, fishing, and hunting. However, the use of live rivers as transport systems could modify or reduce existing recreation conditions. Periods of high flows and depleted flows could occur. Short-term demands may increase for housing during the construction phase, but subsequent demands for housing would probably be minimal. Waterlogging and the resultant wet basements are possible. Short-term demands for public services may increase during the construction phase of the project. In addition, pumping plants would require upgraded electrical service in potentially isolated areas. Therefore, long-term demands may also increase due to required maintenance of new facilities. Some transfer systems can present safety hazards. No particular tax base changes or constraints were identified except when canals are constructed through productive land. In addition, land ownership (private vs. public) along the transport route would have a bearing on future tax revenues.

Population: No particular changes or constraints were identified, although developments may encourage youth to remain in the impacted area, due to employment opportunities, even though such opportunities may be of short duration.

Local Economy: Short-term economic effects may occur during the construction phase in the form of increased economic activity, but long-term benefits along the transport corridor would probably be minimal. Some disruption of certain kinds of economic activity could occur after construction is completed, such as dislocation of center-pivot irrigation due to construction of the transport route.

Attitudes: The construction phase of the project could have some negative effects on area residents due to noise, dust, increased traffic, etc. However, subsequent effects would probably be minimal. Unless local residents objected to a transport project, the effect on social organizations and cohesiveness would probably be minimal except for possible accident hazards or inconvenience to farmers and their families occasioned by a canal running through or adjacent to their land. If public monies are used the question of equity of benefits may help determine attitudes towards the project that tax monies should not be used for projects which directly benefit what they perceive as only a small number of people. The potential would exist for a negative change in the quality of life of area residents in the path of the project during construction from dust, noise, etc. However, long-term effects would probably be minimal.

3. STORAGE AND USE

a. Surface

Many of the social constraints to development of surface-water storage are the same in the area of use as in the area of supply. Some distinct differences are that land use may be affected in the use area by the probable conversion of land from dryland to irrigation farming. Development of irrigation capabilities may lead to increased land prices. However, this increase in the value of land assets could be distributed only to current landowners. It may be capitalized and the succeeding owners may thus receive no benefit. Shoreline properties may increase in value if commercial or residential development are involved. Reservoir construction may provide increased employment opportunities in the local area. In addition, area businesses may be able to supply contractors with construction materials and equipment. Expansion of irrigated acres should also bring about increased economic activity and employment opportunities. Loss of employment could occur in inundated areas if land is taken from production. In addition, over-expansion of local businesses during project construction could lead to a "boom/bust" cycle of employment opportunities and local business activity.

The potential would exist for improved water quality due to importation of water. Local residents may experience reduced concern over water shortages. However, water-related accidents would be a new concern to people who live or recreate near a reservoir, as would be problems of increased automobile traffic and vandalism. Community cohesiveness may increase if water importation was partially a result of local cooperation and lobbying efforts. However, cohesiveness could decrease if importation occurred despite protests. On the other hand, conflict may arise concerning the allocation of supplemental water supplies. Area residents may feel an enhanced or improved quality of life if the project was constructed in an area which previously experienced water shortages for agricultural or domestic uses. Improvements in the local economy would affect the state of satisfaction of local people. Those who prefer economic and population growth would feel an improved quality of life. However, those who prefer the status quo would probably disapprove.

b. Underground

In contrast to the above situations the area of use for supplemental groundwater supplies would be subject to a much different variety of social constraints than the area that might furnish supplemental groundwater.

Land Use: Increased availability of groundwater for irrigation may lead to increased crop production, additional sales of farm products, and increases in gross farm revenues. Increased groundwater storage would probably have little effect on recreation opportunities unless streamflows or wet meadows were positively affected. Changes could include improvement of wildlife habitat, improved streamflows, etc. The demand for both housing and public services may temporarily increase during the construction phase of project. In addition, energy requirements may increase due to groundwater pumping. Thus, long-term increases in public service deliveries may also be required. The local tax base would increase if irrigated acreage increased or if more productive crops could be grown.

Population: An improved economic base could lead to increased population stability in an area. However, the amount of population change would depend on the extent of economic activity. The population composition of an area may remain unchanged or could include increased numbers of young adults and children due to reduced out-migration forces.

Local Economy: The price of land would probably increase or stabilize since increased quantities of irrigation water would improve local crop production. Increased or stabilized agricultural production should lead to some expanded employment potential in the local area.

Attitudes: Local residents may experience less concern regarding water shortages. Community cohesiveness may increase if water importation was partially a result of local cooperation and lobbying efforts. However, divisiveness may occur if problems should arise concerning allocation of supplemental water supplies. Area residents may feel an enhanced or improved quality of life if the project were constructed in an area which previously experienced water shortages. Improvements in the local economy would affect the general state of satisfaction of residents. Those who prefer economic and population growth would feel an improved quality of life. However, those who prefer the status quo would probably disapprove.

If public monies are used some people may have their attitudes affected by questions of equity. The attitude of some people may be that such monies should not be used for projects which they perceive as directly benefiting only a small number of people.

D. LEGAL

Many of the legal requirements described here seem to constrain supplemental water-supply development by requiring that a permit be obtained or that a permit holder be legally liable for damages caused to another. As will be seen, however, these apparent constraints actually facilitate such development in clarifying the developer's water rights and by removing some of the primary objections to supplemental water-supply development. In general, the most serious legal con-

straints in Nebraska water law exist where inadequate or no legislative authorization is available to implement certain supplemental water supply alternatives. Most notable in this regard is the lack of authority for agricultural groundwater transfers. The remaining "legal constraints" usually serve an important socio-political objective in accommodating those who are adversely affected by a particular supplemental water-supply alternative. These legal constraints are discussed in five subsections: (1) surface-water appropriation requirements, (2) underground water storage, (3) surface-water transfers, (4) groundwater transfers, and (5) summary. A more complete description of the legal requirements necessary to obtain surface-water or groundwater rights for supplemental water supply purposes is contained in Appendix D to this report.

1. SURFACE-WATER APPROPRIATION REQUIREMENTS

Persons or organizations intending to appropriate water or to construct a storage reservoir must acquire permits from the Nebraska Department of Water Resources (DWR). These requirements establish a procedure for potential appropriators to follow. They do not generally constrain supplemental water-supply development as the purpose of the appropriation process is to clarify the rights of appropriators to use water. In other words, the general appropriation process facilitates the development of supplemental water supplies. However, the following features of the appropriation process may constrain supplemental water-supply development:

a. Public-interest criterion

All appropriations must be determined by the DWR director to be in the public interest before the appropriation can be granted. While the director traditionally has not made an independent determination regarding whether a particular appropriation is in the public interest, the public interest criterion does give project opponents an opportunity to contest the application. This opposition may raise the cost of obtaining an appropriation by requiring the applicant to defend the appropriation in public hearings against objections raised. Opponents may also appeal the director's decision in court, forcing the applicant to bear the additional costs of litigating the application before the Nebraska Supreme Court. In recently contested applications these procedural costs have been substantial, even leading to unsuccessful legislative attempts to streamline the application process. An advantage of this procedure, however, is that it does give project opponents ample opportunity to point out problems or shortcomings of the proposed project before an irrevocable decision to complete the project has been made.

In addition to the procedural costs imposed, the public-interest criterion may also establish substantive criteria constraining supplemental water-supply development. For example, if two proposed supplemental water-supply projects are applying for the same water, the DWR director (or the Nebraska Supreme Court on appeal) may determine that the public interest is better served by allocating the water to project A instead of to project B. This application of the public-interest criterion constrains the development of particular supplemental water-supply projects, but does not necessarily constrain supplemental water supply development generally (except for the procedural costs described above). More significantly, the DWR (or the Supreme Court) could determine that a proposed project was not in the public interest because it would interfere with environmental or other water uses which better served the public interest. If a proposed project's costs exceeded its benefits, the DWR (or Supreme Court) could similarly determine that the project was not in the public interest, even if there were no competing water use. Either of these applications of the public interest criterion could constrain individual supplemental water-supply projects and supplemental water-supply development generally. This is not to say that these constraints are necessarily inappropriate public policy.

For inbasin appropriations the term "public interest" is not legislatively defined. However, the term has been defined for interbasin-transfer surface water appropriations. Interbasin-transfer statutes require the DWR director to make an independent determination that the appropriation would be in the public interest, and give the director specific criteria to follow in making the public-interest determination. An interbasin-transfer appropriation must be denied if the director finds (after evaluating the economic and environmental costs and benefits of the proposed appropriation and water-supply alternatives) that the benefits to the state as a whole from denying the application are greater than the benefits to the state as a whole from granting the application. This application of the public-interest criterion may constrain supplemental water-supply development insofar as projects which would benefit some people are not undertaken because their negative impacts outweigh their benefits.

In the absence of a public interest or similar requirement, appropriations can be granted if they benefited the applicant. This approach would maximize the opportunity for supplemental water-supply development. This approach would also ignore that the costs and benefits of such development are often disassociated, that one person's benefit may be another person's cost, and that such costs may outweigh the benefits of supplemental water-supply development.

b. Liability for reservoir damage

Reservoir owners are legally liable for damages caused by leakage or overflow from the reservoir. This legal liability may be viewed as constraining sup-

plemental water supply development, as this is a cost of such development imposed on the developer rather than on others. However, the requirement that this cost of supplemental water supply development be internalized (i.e., borne by the reservoir owner) may facilitate such development. Those who would oppose the project because of potential injury from reservoir leakage or overflow may not oppose the project as strongly knowing that project developers will be liable for damages arising from reservoir leakage or overflow.

c. Natural-flow preference

During the irrigation season natural-flow appropriators may divert water which otherwise would be appropriated by senior-storage appropriators. The purpose of this requirement is to force off-season storage during years of low flow. This requirement constrains supplemental water-supply development in that storage-project developers cannot depend on water being available for storage during the irrigation season. Even though adequate water may be available when the project is initiated, the project's summer storage rights may be in effect divested by junior natural flow appropriators.

2. UNDERGROUND WATER STORAGE

Prior to passage of LB 198 by the Legislature in 1983, Nebraska water statutes did not address groundwater storage in a manner similar to surface-water storage. This legal vacuum severely constrained deliberate attempts to store water underground, in that the recharge project operators had no legal security in being able to control withdrawals of water stored underground or to charge for its withdrawal. A related issue was the status of surface-water appropriations when water appropriated for direct irrigation was instead stored underground. A final issue relates to liability for private damages resulting from storing water underground. These significant legal constraints to storing water underground have now been addressed through legislation identifying underground water-storage rights, duties, and authorities, and establishing procedures for modifying surface-water appropriations to reflect the occurrence of underground water storage.

3. SURFACE-WATER TRANSFERS

There are no significant legal obstacles to inbasin surface-water transfers for supplemental water-supply purposes other than those discussed above in subsection 1. Constraints imposed by special requirements relating to interbasin surface-water transfers also have been discussed in subsection 1.

4. GROUNDWATER TRANSFERS

Nebraska statutes explicitly authorize groundwater transfers for public water supply and industrial purposes if a DWR permit has been obtained. Groundwater transfer authorities for agricultural purposes may be inferred from surface-water appropriation statutes and natural resources district (NRD) statutes, although these authorities are unclear. The absence of a clear legislative authorization to transfer groundwater for agricultural purposes is a major constraint to supplemental water development for irrigation.

a. Public water-supply permits

The major requirement for a public water-supply groundwater transfer permit is that the DWR director must find that the proposed withdrawal and transfer of groundwater are "reasonable, not contrary to the conservation and beneficial use of groundwater, and not otherwise detrimental to the public welfare." What constitutes reasonableness in this context is not clear, but it might mean that the amount of water requested is not excessive. What is meant by conservation and beneficial use of groundwater is similarly unclear. These somewhat vague criteria afford the DWR director broad administrative discretion in making groundwater-allocation decisions. The public-welfare criterion is for all practical purposes identical to the public-interest criterion discussed above with reference to surface-water appropriations. These criteria taken together were probably intended to have a meaning similar to the public-interest criterion discussed above, and would have similar procedural and substantive impacts in constraining groundwater transfers for public water-supply purposes. The permit requirement facilitates supplemental water-supply development by clarifying the permittee's water rights similar to the appropriation permit procedure described above. At the same time, it introduces procedural hassles for the applicant. Public water-supply permit holders may be sued by neighboring landowners for interfering with the landowner's groundwater rights. While this may be perceived as a constraint to groundwater development for supplemental public water supply purposes, this requirement also facilitates such development by reducing the legal basis for opposing public water-supply groundwater uses. The absence of such a "constraint" could make groundwater development for public water-supply purposes politically more difficult to implement.

b. Industrial groundwater permits

The major requirement for industrial groundwater use and transfer permits for withdrawals of 3,000 acre-feet or more is that the DWR director may grant the application if the proposed industrial groundwater use would be in the public interest. In making that determination the director must consider the adverse impact of the proposed industrial use on present and future local domestic and agricultural uses, on availability of alternative supplies, on the economic and social benefits

of local water uses and on the proposed industrial use, and whether the applicant has obtained waivers of liability from neighboring landowners. The public-interest requirement is similar to the surface-water appropriation public-interest criterion discussed above, and would have similar procedural and substantive impacts on constraining groundwater transfers for public water-supply purposes. The permit requirement facilitates supplemental water-supply development by clarifying the permittee's water rights, similar to the appropriation permit procedure described above. Industrial groundwater use permit holders may be sued by neighboring landowners for interfering with the landowner's groundwater rights. While this may be perceived as a constraint, it also facilitates supplemental water-supply development by reducing the legal and political bases for opposing industrial groundwater uses. The absence of such a "constraint" could make groundwater development for industrial purposes politically more difficult to implement.

c. Agricultural groundwater transfer

Agricultural groundwater transfers are severely constrained by existing law because such transfer authorities are ambiguous at best. Surface-water appropriation statutes appear to authorize groundwater transfers for agricultural purposes if the stream channel is used as the means of conveyance. The statutes have been so administered by the DWR. Reclamation district and NRD statutes also imply a district right to transfer groundwater for agricultural purposes. These somewhat cryptic authorizations of groundwater statutes stand in stark contrast to Nebraska Supreme Court decisions stating that the legal authority for groundwater transfers in Nebraska are severely limited. This ambiguity could be resolved through legislation clearly authorizing agricultural groundwater transfers. The public water supply and industrial groundwater-transfer permit statutes and the interbasin surface-water statutes may serve as models for any agricultural groundwater-transfer permit statute.

5. SUMMARY

The two aspects of Nebraska surface and groundwater law most constraining supplemental water-supply development are: (1) the preference for junior natural-flow appropriators over senior storage appropriators during the irrigation season, and (2) the absence of clear agricultural groundwater-transfer authorities.

E. INSTITUTIONAL

Supplemental water supply development functions are allocated between local, state and federal agencies. Historically, few real institutional constraints (as opposed to financing constraints) existed to developing a supplemental irrigation water-supply project (in this context, principally a federal supplemental water project). Federal policies were the most important in that they determined how and whether projects would be financed. State and local policies complemented federal policies by enabling whatever legal and institutional authorities were necessary to secure federal funding for the water project. The local governmental entity ("local sponsor") was responsible for organizing the local water district (irrigation district, reclamation district, etc.), promoting the project locally and in Congress, and sometimes for project operation and maintenance. The state's role was granting necessary water rights, as well as providing legal authorization for the project sponsor to organize and obtain taxing authority to finance its promotional and other operations. The federal government analyzed project feasibility, financed the project through the program (as funds were available), and supervised project construction. Under this system the major requirements for obtaining a project were (1) for the local sponsor to organize the water district, (2) for the necessary water rights to be obtained, and (3) for Congress to finance project construction. The only real constraint in this system was Congressional funding, which depended largely on (1) whether the proposed project could meet federal cost-benefit tests and (2) whether federal funds were available for the project. In other words, if the local sponsor took the initiative to organize and to obtain local political support and funding and the necessary water rights, and if the proposed project met the federal financial feasibility tests, and if federal funds were available for project construction, few if any other institutional factors traditionally constrained developing supplemental-water projects. A detailed discussion with references of the current institutional setting at the federal, state and local levels can be found in Appendix E to this report.

More recently the traditional approach to developing federal supplemental-water projects has changed in two important ways: (1) environmental considerations now must be more carefully evaluated in project planning and (2) future federal financial assistance may be contingent upon significant state and local funding. Under these new circumstances, the major institutional constraints to developing supplemental-water projects are environmental and financial in nature. The discussion of these constraints is presented in four subsections: (1) environmental institutional constraints, (2) financial institutional constraints, (3) organizational aspects, and (4) summary.

1. ENVIRONMENTAL INSTITUTIONAL CONSTRAINTS

a. Federal environmental laws

For the past decade the federal environmental con-

straint to developing federal supplemental water projects has been the National Environmental Policy Act (NEPA) requirement that environmental impact statements (EISs) be prepared for every major federal action significantly affecting the quality of the human environment. NEPA does not require federal agencies to minimize environmental disruption in their activities, so NEPA does not forbid construction of environmentally disruptive water projects. NEPA simply requires that an accurate environmental assessment be prepared. However, federal agencies have often attempted to minimize the environmental consequences of their proposed actions in the EIS. In these circumstances, EISs have been challenged in court by project opponents, and often have been determined to be legally inadequate. If the EIS is inadequate, it must be revised until the court is satisfied with its adequacy. Where federal agencies have attempted to minimize the adverse environmental impacts of proposed projects in the project EIS, court challenges often have provided an effective mechanism for project opponents to delay project implementation. While the EIS process can be an opportunity to identify and evaluate ways to minimize environmental disruption from a project, it can also be used by opponents as a way to stop the project. The O'Neill Unit (Norden Dam) is an example of a federal supplemental-water project in Nebraska which has been delayed through NEPA litigation. Another federal law, the Wild and Scenic Rivers Act, can have a similar effect.

A second federal environmental law deserves special mention in this context. The federal Endangered Species Act requires federal officials to take all steps necessary to insure that federal actions (1) do not jeopardize the continued existence of federally identified threatened or endangered wildlife species, or (2) do not modify or destroy such species' habitats which are federally identified as critical habitats. These requirements apply to federal supplemental-water development programs. The U.S. Department of the Interior has identified critical habitat for the endangered whooping crane in the Middle Platte River basin, which may significantly constrain supplemental-water project development using or affecting Platte River water. The critical habitat designation may also provide a significant measure of protection to that habitat and the wildlife species the habitat supports.

b. State environmental laws

The state environmental law most likely to affect supplemental-water project development is the Nebraska Endangered Species Act. The Act requires all state agencies to consult with the Nebraska Game and Parks Commission to determine whether any proposed state activity (1) will jeopardize the continued existence of a wildlife species designated by state or federal officials as being threatened or endangered, or (2) will jeopardize the species' habitat determined by the Commission to be critical. The Act also prohibits state agencies from taking action jeopardizing the continued existence of threatened or endangered species or destroying their commission-identified critical habitat. The Act has been interpreted by the Nebraska Supreme Court as applying both to the water-right granting procedures of the Nebraska Department of Water Resources (DWR) and to the water-development activities of local project sponsors. The Act could significantly constrain supplemental-water development if projects would not be developed because they would jeopardize the continued existence of threatened or endangered species or their critical habitat.

2. FINANCIAL INSTITUTIONAL CONSTRAINTS

Traditionally, as noted above, the only real constraint to federal supplemental water project development was whether the proposed project met federal financial feasibility criteria, and whether federal funds were available for project construction. If a project qualified for federal funding, and if federal funds were available, no state funds and only limited local funds were required. This appears to be changing. While new federal financing policies are not clearly established, (including federal financial feasibility tests) states (including local project beneficiaries) may be required to put up as much as one-third of the project costs in order to qualify for federal project funding. This means that unless significant state and/or local water-development funding sources are developed, the likelihood of constructing additional large federal surface-water projects in Nebraska is remote (unless federal funding policies change).

While existing state water-development programs are designed to complement the traditional federal supplemental-water development programs, they may not be politically geared to the changing federal program requirements. In order to qualify for federal financial assistance, state and local programs could be modified to generate additional funding for supplemental-water programs. (A discussion of federal programs assisting municipal water supply development is contained in the *Policy Issue Study on Municipal Water Needs.)* To qualify for federal financial assistance, state and local programs could be modified to generate additional funding for supplemental-water programs. However, local sponsors probably have adequate legal authorities to currently qualify for federal financial assistance. Natural resources districts, reclamation districts, and irrigation districts are currently authorized, in various instances, to levy property taxes, to enter into water sales contracts, and to issue bonds to finance water-project development. Using existing authorities, additional funds could be obtained (1) by requiring water users to pay a greater share of project costs through increased water use fees, or (2) by levying a higher property tax in the project area. Existing authorities may not generate the needed funding

to qualify for federal financial assistance, (1) if local water users are politically unwilling or financially unable to pay high enough water-use fees, (2) if local taxpayers are politically unwilling or financially unable to pay high enough taxes to qualify for federal assistance, or (3) both. In such case, new water-development funds could be obtained (1) by increasing the costs to other project beneficiaries (e.g. charging for flood-control benefits, recreational uses, etc.), (2) through expanding the Nebraska Resources Development Fund through a state-wide water use fee, (3) by direct state appropriations for water development, (4) through state-issued revenue bonds and general obligation bonds, or (5) through some combination thereof.

An additional issue is raised if the state provides substantial financial assistance for supplemental water-supply projects. As currently administered by the Nebraska Natural Resources Commission, proposed projects must have a positive financial return in order to qualify for Nebraska Resources Development Fund funding. One problem in evaluating the costs and benefits of proposed water-resources projects is the inability to accurately evaluate the indirect regional economic benefits from such projects. This makes it difficult to determine whether a proposed project will have a positive financial return. In more general terms, the state financial feasibility test does restrict supplemental-water development by preventing development of financially infeasible projects. On the other hand, such a policy establishes that public funds will be spent for projects having the greatest net economic benefits (assuming realistic appraisal of indirect project economic benefits).

3. ORGANIZATIONAL ASPECTS

One difficulty with supplemental-water project development is that local sponsors often lack full-time professional staff to shepherd a proposed project through the state and federal administrative and political process. Relying on volunteers (e.g., locally elected reclamation district directors) to perform this task may limit the effectiveness of local sponsors. This is less of a difficulty now in Nebraska with the advent of natural resources districts, which have full time professional staff. Developing supplemental water projects might be facilitated, additionally, if a state agency were granted project planning, development, financing and construction authorities, similar to the California Department of Water Resources or the U.S. Bureau of Reclamation. Current state and local institutional arrangements do not seem to constrain supplemental water-supply development. Such development might be facilitated further by establishing a state supplemental water-supply development agency.

4. SUMMARY

The major institutional constraints to supplemental-water project development are environmental and financial. The major federal environmental constraints is that many proposed projects could cause environmental problems and thus may be politically challenged because of material contained in the environment impact statement or legally challenged because some parties may not believe the statement is adequate. Another instance where institutional protection of the environment may constrain project development in Nebraska is the Platte Whooping Crane Critical Habitat designation. The major state environmental constraint is the requirement that state actions not jeopardize the continued existence of threatened or endangered species or their critical habitat. The major financial institutional constraints seem to be (1) the availability of federal water resources development funds and (2) the conditioning of that funding on the availability of significant state and local funding. While the latter factor will increase the cost to Nebraskans of federal supplemental water projects, the possible changes in federal financing policies may not necessarily constrain project development to the point it does not occur. However, the required local financing could come either from higher water use charges, higher local and/or state taxes, or some combination thereof. These changes may prove to be financially, and therefore politically, constraining.

F. ECONOMIC

Since the 1930s, federal decisions regarding investment in water-resource development depended upon a benefit-cost or economic-efficiency criterion. An investment was considered feasible only if economic benefits exceeded the costs of the investment. Lewis, et al. (1973) cite a broader set of objectives, suggested by the Water Resources Council, to consider in evaluating water resources investments. The quotation from the guidelines is as follows:

> "The overall purpose of the water and land resource planning is to reflect society's preferences for attainment of the objectives defined below:
>
> A. To enhance national economic development by increasing the value of the Nation's output of goods and services and improving national economic efficiency.
>
> B. To enhance the quality of the environment by the management, conservation, preservation, creation, restoration, or improvement of the quality of certain natural and cultural resources and ecological systems.
>
> C. To enhance regional development through increases in a region's income; increases in employment; distribution of population within and among regions; improvement of the region's economic base and educational, cultural, and recreational opportunities; and enhancement of its environment and other

specified components of regional development."

The authors suggest that these goals lend recognition to the concept that public investments in water resources have a broader range of implications that reach beyond economic efficiency (Lewis, et al., 1973). Although these goals were delineated from a perspective of national resource planning they are also relevant at the state or regional level.

When considered from this broad perspective, one must consider economic constraints in terms of total economic gains and losses, and to whom they accrue, and not merely in terms of a conventional benefit-cost ratio. Economic constraints are addressed in the first subsection by discussing the types of economic impacts, both positive and negative, to be expected from water development. In the second subsection selected empirical examples of water-development projects are used to illustrate the magnitude of expected economic impacts. This information is then used in the conclusion to draw inferences regarding when and how economic factors constrain water development.

1. PRINCIPAL ECONOMIC IMPACTS FROM WATER DEVELOPMENT

Economic impacts can be classified into two broad categories: primary and secondary. The primary impact category includes the positive effects (benefits) and the negative effects (costs) that are technically linked to the water project. This category can be further divided into direct and indirect, where direct refers to immediate water uses, whereas indirect refers to some technical consequences of a water use. Secondary economic impacts, on the other hand, are the positive and negative effects which accrue to the rest of the economy as a result of the construction and operation of the water project.

a. Primary economic impacts

There are several potential sources of primary beneficial and negative economic impacts from water projects in Nebraska. Primary benefits could be derived from a project through use of water for irrigation purposes, water based recreation, electric power generation or flood control or through reduced pumping costs due to water that recharges the groundwater reservoir as a result of impounding and distributing surface water. The primary negative impacts or costs include project construction and operating expenditures.

Irrigation benefits: Of all the sources of primary beneficial economic impacts (benefits) from water development, irrigation is the most important for most of the development opportunities in Nebraska. The primary economic benefits from irrigation that are associated with a water development are equal to the value of increased net income that can be attributed to irrigation. These primary impacts are estimated by determining what the net income from project lands would be without the project and finding the difference between that value and the net income that would be expected if the project was constructed. The level of primary benefits from irrigation depend upon the before-project use of the land and the potential use of that land if the project was constructed. Primary irrigation benefits would be highest for the cases where the lands to be irrigation would be several times the net income per acre for livestock grazing.

A second level of primary benefits for an irrigation project would be the case where lands to be irrigated are currently used for dryland cropping activities. The primary benefits would usually be less for this case than they are where range livestock is the best without project use of the land, because the with and without net income differences are less.

A third case occurs in situations where surface water completely replaces groundwater as the source of supply on currently irrigated lands. In this situation the primary benefits are even less than they are in the dryland to irrigated cropping case. The direct benefit would still be in the difference between net income with and without the projects, but the difference in net income would only amount to the cost savings from not having to lift water from the groundwater reservoir.

Recharge benefits: Another type of primary economic benefit that might result from a water development, particularly an irrigation project, is the benefit that would accrue from project water that percolates into the groundwater reservoir. The water that recharges the groundwater reservoir could provide benefits by raising the static water level, thus reducing the distance that water would have to be lifted in wells; by increasing the yield of the wells in the affected area or by extending the life of the groundwater reservoir (Supalla and Comer, 1981).

Primary economic benefits from recharge will vary widely depending upon the characteristics of the groundwater reservoir involved and the projected use of the groundwater.

Hydroelectric power benefits: Another source of primary benefits that could occur from a water development is the benefits derived from electrical power generation. The magnitude of the power generation benefits depends upon how much electricity can be generated for any given project and the market value of that electricity. The market value of the electricity depends upon the prevailing supply and demand situation for electric power. How much electricity can be generated for any project is a function of the technical aspects of the project.

Recreation benefits: Water-based recreation activities are another source of potential primary benefits from water development. Among the most

common recreational activities associated with storage-reservoir activities are swimming, boating, water skiing and fishing. In most cases the primary benefits from water-based recreation are estimated based upon the number of annual visitor-days for each activity times a willingness to pay value per visitor-day. The value of a visitor-day of any given activity is somewhat invariant from one project to another. However, the number of visitor-days of each activity may vary substantially from one project to another. The variation in the number of visitor-days is essentially a function of the population density in the surrounding area, availability of other water-based recreation in the surrounding area and whether or not the project has the attractiveness to bring in distant recreationists.

Flood control benefits: A final major source of potential primary benefits from water development is the reduction or elimination of damages caused to property by flooding. The major primary benefits from flood control are dependent upon how much property is in the flood plain and the value of that property and how much it would be damaged in the absence of the surface-water development. Another primary benefit of flood control which may be significant in some cases is the reduction in inconvenience, such as not having to detour around a washed-out bridge. This would usually be referred to as an indirect primary benefit.

Primary costs: Economic impacts which have negative consequences are generally referred to as costs. The primary direct costs of water development includes the value of the resources used in constructing the project (land, labor, and materials) and the costs of operation and maintenance once the project comes on line. The market value of the resources used in this project construction represents a measure of what is given up to have the project and is thus a negative economic impact. The relative magnitude of such costs is illustrated in the empirical example found later in this section. In addition to primary direct costs, many water projects often have primary indirect costs. These are costs which are appropriately measured and included in a benefit/cost analysis when data permit, but are usually treated as associated impacts and not measured in dollars. Examples include environmental and social impacts. These topics were treated in Sections A and C of this chapter.

b. Secondary economic impacts

As defined earlier, secondary economic impacts are those changes in economic activity that accrue to people and businesses that are not direct users of the water involved. The important secondary economic impacts of water development were defined to include four items or categories: business volume, employment, population, and personal income. Secondary economic impacts result from the interrelation of the sectors in an economy, with the original impetus coming from those sectors that are direct water users. Although both secondary benefits and secondary costs occur, conventional practice is to address them collectively, using a net impact concept.

In order for secondary impacts to occur there has to be a change in economic activity in at least one sector of the economy beyond that which would occur without development. The change in activity or output for that sector will require a change in the amount of inputs that sector will purchase from other sectors to produce that output. The purchase of additional inputs from the supplying sectors will require additional purchases from still other sectors and thus a chain reaction throughout the economy will occur. This change in economic activity also influences employment and, consequently, population. The change in business volume or gross state output, employment, and population may result in a change in personal income available for consumer purchases which would filter through the economy, thus further influencing activity in the economy. Simply stated, secondary economic impacts are a result of the spending and respending of a change in the value of output generated by the sector of the economy that is directly impacted by a surface-water development.

Whether secondary impacts will occur in an economy depends upon the nature of the primary economic impacts of a water development. The conditions that are required are: (1) there must be a change in the level of economic activity in the directly impacted sector of the economy that would not have occurred if the development did not take place; (2) the directly impacted sector must be interrelated with other sectors in the economy; and (3) the change in economic activity generated by a development must be a real change and not merely a relocation of economic activity from one geographic region of the economy to another.

Secondary impacts from irrigation: The flow of secondary economic impacts that might be associated with a change in the value of agricultural production due to irrigation from a water development would take the following path. A change in the value of output from the irrigated sector of the economy means increased exports or sales to people outside the state. Producing this increased output would require increases in the purchases of inputs from those sectors that supply irrigated agriculture. The increased sales by the sectors that supply agricultural inputs would mean that those sectors would also increase their purchases from still other sectors. This series could mean some changes for virtually all sectors in the economy. The change in the level of output from the irrigated agriculture sector could also begin a series of changes in those sectors of the economy that handle and process that output and consequently those sectors that supply goods and services to them. The change in agricultural production, along with the

associated changes that would occur in the supplying and processing sectors, together with the series of changes that would filter through the entire economy would constitute a change in total business volume within the economy that is several times as large as the initial change in the value of agricultural output. Associated with the change in total business volume would be a change in the level of employment in the economy. Assuming a full employment or near full employment economy (everyone who wants a job has one), then a change in the employment level would imply that the state's population would also change. The change in business volume from the initial round of impacts and the changes in employment would mean that personal income (amount of money that people in the economy have to spend on consumer goods and services) would also change, inducing further impacts throughout the economy.

If the primary impact of an irrigation project results in a net change in the level of output from the irrigated sector, then the final state-level secondary impacts (changes in business volume, employment, population, and personal income) could be several times (a multiplier effect) what one would expect if only the direct impacts of the project were considered. Actual values for these impacts are addressed later in this report.

Indirect impacts from incidental or accidental recharge: The magnitude and direction of secondary economic impacts associated with groundwater recharge depend upon the nature of the primary impacts from recharge. If the recharge only reduces the pumping lift of the irrigators in the area, the primary impact then is lower energy use and higher net returns for those using groundwater. The secondary impact flows from lower energy use and reduced sales for the energy sectors of the economy. Less business volume in the energy sectors may in fact reduce the business volume of related sectors and potentially cause reductions in employment and personal income in the economy. However, higher net returns in the irrigated agriculture sector may mean increased personal income in that sector, which may serve to offset the negative indirect impacts that would be associated with reductions in energy use. The net secondary impact in this case may be positive, negative, or zero, but in most cases the secondary impact should be small.

If the recharge from a water project makes it possible to irrigate lands with groundwater that would not otherwise be irrigated, then the primary impact of recharge would be equal to the additional net income from those lands. The flow of secondary economic impacts in this situation would be the same as those from surface-water irrigated lands, as discussed earlier.

Secondary impacts from hydroelectric power: Primary impacts from electric power generated in conjunction with a water development may produce secondary economic impacts as long as the primary impacts constitute a net change in total energy production within a state or region. If the electricity from the development replaces electricity generated by another source within the same region, or if it substitutes for other types of energy, then the secondary impacts may be small or nonexistent. For that situation where the primary impacts result in an increase in total energy production in the economy, some of which is exported, then the business volume of the energy sector and those sectors that supply the energy sector will change. That change then will filter through the economy and result in the generation of secondary economic impacts. The secondary impacts may consist of changes in business volumes, employment levels, population or personal income, or in all of these areas. In the usual case, however, secondary impacts from hydroelectric power will be near zero because one energy source offsets another. Such offsets are often called secondary costs.

Secondary impacts from recreation: Although the benefits or values of the water-based recreation which might occur as a result of constructing a project certainly constitute a primary economic benefit, this does not imply a monetary flow for water-based recreation. For this reason, it is difficult to assess secondary impacts from recreation even though a change in water-based recreation could result in changes in economic activity and hence generate secondary economic impacts. A change in water-based recreation would imply a change in purchases by those who participate, thus a change in the level of business volume in those sectors which would experience additional sales. If those who recreate happen to be primarily residents of the economic region of interest, then the net secondary impacts would likely be small, because additional expenditures in one area are offset by fewer expenditures elsewhere in the region. However, if a substantial portion of those taking part in water-based recreation come from outside the economic region, then the net secondary impacts from recreation would be somewhat larger due to changes in economic activity in the tourism industry.

Secondary impacts from flood control: Perhaps the most elusive flow of secondary economic impacts that might result from a water development are those associated with flood control. From the perspective of a national full-employment economy, it is clear that the secondary impacts from reduced flood damages approach zero, because resources not used in repairing flood damages are fully employed doing other things. From a state perspective the situation is much less clear, however. If flood damages mean an inflow of dollars to the state (disaster programs, insurance, etc.) which is greater than the actual damages, then there would be negative secondary im-

pacts from flood control. On the other hand, these negative secondary impacts could be offset if flood control results in attracting additional business firms to the region (state) that would otherwise locate elsewhere. In total, it is usually reasonable to assume that the net secondary impacts from flood control are zero for any region of interest.

2. EMPIRICAL ILLUSTRATION OF ECONOMIC IMPACTS FROM SURFACE-WATER DEVELOPMENT

Several proposed surface-water developments were selected to serve as illustrations of the potential range of primary and secondary economic impacts that might be expected from such developments. The projects selected were the North Loup project in central Nebraska, the O'Neill Unit in north central Nebraska, the Little Blue project in the south central part of the state, and the Prairie Bend project located in the Middle Platte drainage basin.

a. Direct economic impact values

The estimated primary benefit and costs for each impact source are listed in Table 4-1. The estimates shown represent the results of the most recent feasibility studies indexed to 1981 dollar values. No attempt was made to determine whether the reported estimates of costs or benefits were correct or biased, except for the changes in irrigation benefits which are noted in footnotes to Table 4-1.

The major source of primary benefits for all of the selected surface-water projects was irrigation. Direct annual economic benefits from irrigation were estimated at $8.5, $13.3, $10.7, and $6.6 million for North Loup, O'Neill, Little Blue, and Prairie Bend, respectively.

Primary economic benefits from recharge, although significant, especially in the case of Prairie Bend, were not available for all projects. Likewise, recreation benefits are potentially quite significant, but estimates were available only for North Loup and O'Neill. Flood-control benefits were relatively small or zero in all cases and none of the projects had a hydropower component.

The estimates of total primary economic benefits correspond to the total annual return that is available to pay for federal projects. As noted earlier, there are no secondary economic benefits from a federal perspective, because such changes merely amount to the relocation of economic activity (secondary benefits are offset by secondary costs). Thus, one can compare total direct economic benefits to annual costs at different interest rates to determine which projects would generate a rate of return at least equal to the cost of capital. This analysis reveals that all of the example projects are economically efficient (have a benefit/cost ratio greater than one) at an interest rate of 3 percent, only the Little Blue and Prairie Bend are efficient at 5 percent; and none of the projects are economically efficient at 8 percent or more.

b. Secondary economic impact values

The methodology used to determine the secondary economic impacts of surface-water development was input/output analysis. Input/output analysis makes use of inter-industry relationships to derive a table of transactions expressing the relationships between the purchases and sales of each economic sector. From this table of interindustry transactions, several kinds of multipliers can be estimated. Such multipliers can be used to compute the total change in economic activity which results from a specified change in one sector of the economy as that change filters through other sectors of the economic system. The input/output multipliers used in this analysis were based on an updated 1976 transactions table for Nebraska (Lamphear, 1982). Secondary impacts were estimated only for irrigation and for that portion of recharge benefits which reflect increased irrigation. This approach is consistent with the earlier discussion where it was noted that in the general case secondary impacts from other water uses net out to near zero from either a state or a national perspective. In estimating total output impacts from irrigation, the output multipliers used were 2.324 for irrigated agriculture and 2.062 for dryland agriculture. These multipliers were applied to estimated changes in the value of irrigated and dryland production, respectively, to determine an annual change in total state output for each project (Table 4-2). Estimated state output effects per acre-foot diverted ranged from $182 for North Loup to $264 for Little Blue. These estimated changes in gross state products are essentially business volumes or sales and should not be construed as economic benefits for use in determining economic efficiency. Only the personal income portion of these output effects can be treated as a potential economic benefit in the sense that benefits are what one could afford to pay and be at least as well off as one would be without the project.

c. Secondary income effects

That portion of secondary output effects which amounts to a potential economic benefit can be estimated using income multipliers. Income multipliers measure the changes in personal income associated with some primary impact in this case irrigation. The income multipliers used were 1.06 for irrigated production and 0.674 for dryland production. Potential changes in annual secondary economic benefits (personal incomes) were estimated by multiplying changes in irrigated and dryland production by the above multipliers and subtracting the primary irrigation benefits. The resulting values ranged from $52 per acre-foot diverted for the O'Neill project to $94 per acre-foot diverted for Little Blue. In interpreting these results the reader is cautioned to recall that indirect income effects amount to economic benefits only where there is no offsetting changes in economic activity. From a

TABLE 4-1

ESTIMATED DIRECT BENEFITS/COSTS FOR SELECTED PROPOSED WATER PROJECTS[a/]

PROPOSED PROJECTS [b/]

Direct Benefits and Costs	North Loup	O'Neill	Little Blue	Prairie Bend
	$000's			
Direct annual benefits[c/]				
Irrigation	8,306	12,166	10,507	5,056
Groundwater recharge	-------	-------	96	1,577
Recreation	155	1,058	-------	-------
Flood Control	-------	37	120	-------
Total	8,461	13,261	10,723	6,633
Investment Costs	178,034	261,300	130,640	89,512
Annual costs[d/] (50 year period)				
3% interest	7,592	11,084	5,878	3,960
5% interest	10,441	15,242	7,956	5,384
8% interest	15,270	22,289	11,480	7,799
12% interest	22,201	32,406	16,538	11,265
B/C ratio				
3% interest	1.11	1.20	1.82	1.68
5% interest	.81	.87	1.35	1.23
8% interest	.55	.59	.93	.85
12% interest	.38	.41	.65	.59

a/ Direct annual benefits and investment costs are as reported in the latest available feasibility studies indexed to 1981 values, except for irrigation benefits, which were assumed to be $158 per acre, reflecting year 2000 conditions in 1981 dollars. Irrigation benefits were standardized across projects based on High Plains Study results in order to allow for more realistic comparisons.

b/ The amount of water assumed to be diverted for each project was 137,400; 225,500; 120,000; and 85,000 acre-feet for North Loup, O'Neill, Little Blue, and Prairie Bend, respectively.

c/ Missing values for benefit categories reflect missing data and not necessarily a benefit level of zero.

d/ Includes operation and maintenance charges.

Source: R. J. Supalla

TABLE 4-2

IMPACTS ON GROSS STATE PRODUCT, PERSONAL INCOME, EMPLOYMENT AND POPULATION FOR SELECTED PROPOSED WATER PROJECTS

Type of Indirect Offset	North Loup	O'Neill	Little Blue	Prairie Bend
Change in annual gross state product				
Total ($)	25,032,992	44,992,416	31,666,236	18,094,992
Per AF diverted ($)	182	199	264	213
Potential indirect personal income effects				
Total ($)	8,940,319	11,785,622	11,304,629	6,459,789
Per AF diverted ($)	65	52	94	76
Potential change in annual employment				
Total (people)	240	232	304	180
Per AF diverted (people)	.0017	.0010	.0025	.0021
Potential change in population				
Total (people)	494	888	326	375
Per AF diverted (people)	.004	.004	.003	.004

Source: R. J. Supalla

national perspective there are almost always near-equivalent offsets (more income in Nebraska means less in other states) and if state funds are used there may also be equivalent offsets depending on what the funds would otherwise be used for. Succinctly stated, about the only situation where the full estimated income effects would amount to net economic benefits is where only Nebraska's interests are considered and federal funds (grants) that would not otherwise be available to Nebraska are used.

d. Employment and population impacts

The estimated changes in gross output imply changes in employment and population. Based on current employment levels per $1,000 of output, it was estimated that when in operation the four projects would increase employment by 240, 232, 304 and 180 people, for North Loup, O'Neill, Little Blue, and Prairie Bend, respectively. This amounts to approximately two persons per 1,000 acre feet diverted. The employment effects during the construction phase would be substantially larger, but the data for estimating them are not available at this time.

The employment changes can be used to estimate population impacts by multiplying the number of people employed times a labor force participation rate (people per job). The current rate for Nebraska is about 2.05 people per job; thus the population impacts are essentially double the employment impacts.

3. CONCLUSION

There are two economic factors which potentially constrain water development: (1) the identification of projects where the investment generates net benefits at least equal to what the funds would have generated elsewhere, and (2) the availability of funds to finance economically efficient projects. With respect to economic efficiency, the analysis of selected projects reveals that there exists at least some economically efficient development alternatives, once interest rates decrease to more conventional levels.

In view of the large expenditures required, however, it seems likely that the most limiting economic constraint will consist of the difficulties in financing economically efficient projects. Even though a detailed treatment of project financing is outside the scope of this study, Section E of this chapter and Sections D, E, and F of Chapter 5 do discuss institutional approaches to funding and alternatives to the existing conditions.

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D. LEGAL
See Appendix D

E. INSTITUTIONAL
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Chapter 5

Alternative Actions for Legislation and Management and Their Impacts

This chapter presents alternative legislative and management actions related to supplemental water supply. It also examines the potential impacts of those actions. The opening section discusses current policies. Remaining sections present changes in current policies which could encourage the development of supplemental supplies.

The discussion of current policies in Section A contains a legal review in summary form of those policies, an examination of groundwater-reservoir management as a water-conservation policy and a review of the current state policy for financing water development. The section concludes by exploring the impacts of continuing these policies.

Section B examines the concept of integrated management and presents an alternative action addressing that topic. Section C identifies legislative water rights changes that may enhance supplemental water development. Section D considers potential changes in state and local sources of funding for water development. Legislative and management changes in five existing programs are discussed in Section E. Section F presents three new programs which could encourage development of supplemental water. Sections B through F also include a discussion of the possible impacts from these alternatives. Finally, Section G examines the potential for combining alternatives.

The alternative actions presented in Sections B through F of this chapter would encourage development of supplemental water supplies. There may be alternatives for change which would discourage the development of supplemental water supplies. However, an examination of such alternatives was determined to be beyond the charge of the study task force which prepared this report.

A. CONTINUE PRESENT POLICIES

Through the years since 1867 the legislatures of the State of Nebraska have enacted a wide range of laws that deal with water in the state. Some aspects of water are not addressed in state law because the need has not existed or has not been justified. Some water management practices have evolved through expediency and others await development. Court decisions have effected some water management policies. Together, these conditions create an existing state water policy. The development of supplemental water supplies is one area influenced and controlled by this policy. This section summarizes the extent of this existing influence and control. The summary is presented under six headings: surface-water storage, underground water storage, surface-water transfer, groundwater transfer, groundwater-reservoir management and financing water development. The impacts of continuing the present policies conclude this section. A more detailed description of the policies as outlined in Subsections 1 through 4, below, and references can be found in Appendix D to this report.

1. SURFACE-WATER STORAGE

Current surface-water appropriation statutes generally facilitate the development of supplemental water supplies. Public and private entities may develop surface-water storage facilities in Nebraska. Several public entities are specifically authorized by Nebraska law to develop surface-water storage facilities for irrigation, including reclamation districts, irrigation districts, public power and irrigation districts and natural resources districts. Any entity, public or private, intending to develop surface-water storage facilities must comply with surface-water appropriation requirements to appropriate surface water, to construct a storage reservoir, to impound water in a reservoir and to use water stored in a reservoir.

2. UNDERGROUND WATER STORAGE

Until the Legislature enacted LB 198 during the 1983 session Nebraska water statutes did not address the storage of water underground in the same manner as storage of water on the surface. Recharge operators had no legal security in being able to control withdrawals of water stored underground or to charge for its withdrawal.

LB 198 distinguishes between natural groundwater, water that is incidentally stored underground, and water

that is intentionally stored underground. Incidentally stored groundwater is that which occurs as an indirect, unplanned purpose of a water project or water use. It includes seepage from reservoirs, canals, and laterals, and deep percolation from irrigated fields. Intentional underground storage occurs as the intended result of a water project or use. Any "lawful" method may be used, including injection wells, infiltration basins, canals, and reservoirs.

INCIDENTAL RECHARGE

Any person having a perfected surface water appropriation may apply to DWR for a modification of their permit to recognize the incidental underground storage that has occurred pursuant to the exercise of the permit, and to authorize the recovery of that water. In approving the application, the director may not increase the rate, quantity, or time of the surface water withdrawal from that provided in the original permit, nor can the priority date be changed. If the water stored, or to be stored, is to be used for irrigation, the director may authorize the permittee to provide water service to lands not included under the original appropriation if the change is in the public interest and any interference with the rights of senior appropriators is unavoidable and not material. An order approving an application for modification of an existing permit will have to identify the water stored or to be stored.

Anyone obtaining approval for a permit modification can then levy an annual fee or assessment of 50 cents per acre irrigated by mechanical means from the incidentally stored water. No fee or assessment may be levied for withdrawals from domestic wells.

INTENTIONAL RECHARGE

Permits to appropriate surface water for intentional storage of water underground and recovery can also be obtained. Unapproved applications pending on the effective date of LB 198 and approved but unperfected permits may be amended to include intentional underground storage and recovery. Applications for recovery of water stored underground can be approved only if the applicant can demonstrate "sufficient interest in the underground water storage facility to entitle the applicant to the water requested."

Holders of permits for intentional storage of water underground from projects not existing on the effective date of LB 198 may, with the approval of DWR, levy a charge "against any person for the right or probable right to withdraw or to otherwise use such stored water." The charge can vary but is to be based on the amount of storage that has occurred or probably will occur. The charge cannot represent more than the fair market value of the recharge unless necessary to amortize the operation, maintenance, repair, and capital costs of the facility, "apportioned on the degree to which recharge has occurred or is likely to occur, and on the degree to which any surface water is delivered." Charges may not be levied for the withdrawal of stored water from domestic wells.

Fees or assessments will become a lien against the property benefited or to be benefited. Unpaid charges may be recovered by suit in district court to foreclose the lien or recover the amount due. Suit can also be instituted to enjoin any person who has not entered into an agreement to pay the fee or assessment, or has failed to pay the charge for thirty days after it has become due. An order of the director identifying stored water or water to be stored or approving the charges to be levied cannot be collaterally attacked in proceedings to collect charges due or enjoin unauthorized uses. In other words, the fee schedules will have to be challenged at the time they are approved by DWR. Appeals of the director's decisions or orders will go directly to the state supreme court.

If the appropriate permits for incidental or intentional underground storage have not been obtained or if charges have not been approved, any person can use the stored water.

3. SURFACE-WATER TRANSFER

Surface water may be appropriated for use within a river basin if unappropriated water is available and if the proposed appropriation is not detrimental to the public welfare. Surface water from one river basin may be appropriated for use in another river basin if unappropriated water is available and if the proposed appropriation is not detrimental to the public welfare. The interbasin transfer appropriation can be granted, after considering the economic and environmental costs and benefits of the proposed appropriation and water-supply alternatives, if the benefits to the state of granting the appropriation outweigh the benefits to the state from denying the application. In addition, the appropriation cannot be authorized if it would interfere with the continued existence of threatened or endangered species or their habitat.

4. GROUNDWATER TRANSFER

Nebraska statutes allow very limited and specific groundwater transfers, i.e., the transportation of groundwater off-site for use at another location. The Nebraska Supreme Court has stated that the common law rights of overlying landowners to use groundwater do not include the right to transfer groundwater, but that groundwater transfers may be legislatively authorized. Nebraska groundwater statutes specifically authorize interstate groundwater transfers for any purpose, and instate groundwater transfers for public water-supply purposes and for industrial purposes. Groundwater transfers for agricultural purposes have not been specifically authorized by statute, but transfer authori-

ty may be inferred from natural resources district, reclamation district, and surface water appropriation statutes, although these authorities are unclear.

5. GROUNDWATER-RESERVOIR MANAGEMENT

The conservation of water can be a method for delaying or eliminating the opportunity for use of supplemental water supplies. In Nebraska only two policies on water conservation have been enacted as law. One is a funding program, the Soil and Water Conservation Fund, which is mentioned later in this section and is discussed in Section E of this chapter. A second policy addresses groundwater conservation through management of groundwater reservoirs. The state laws which allow for the extending of the life of a groundwater reservoir (Neb. Rev. Stat. §46-656 to 46-673, 46-673.01 to 46-673.13 and 46-674) could reduce the need for supplemental water development.

6. FINANCING WATER DEVELOPMENT

Major policies affecting the development of supplemental water projects are the provision of funds and the ability to raise funds to construct the projects. A "continue present policies" scenario is very difficult to establish for this aspect of the development process. This difficulty exists because historically the major source of funds for development of such programs has been the federal government. In recent years these programs have either been halted, or not funded pending their reevaluation. A continuation of present federal funding policies and levels for supplemental water projects currently seems unlikely at worst and impossible to estimate at best. The state and local level of funding has been minimal for supplemental water project development. The Resources Development Fund has since its inception in 1974 received total state appropriations of $14,111,800 or an annual appropriation averaging about $1,568,000. The Soil and Water Conservation Fund has since its inception in 1978 received total state appropriations of $4,562,660 or an annual appropriation averaging about $912,000. Politics and legislative directives have caused these funds to be used for a large number of projects on a state-wide basis. Local governments have had very limited funds to contribute to any supplemental water projects.

7. IMPACTS OF CONTINUING PRESENT POLICIES

The impacts of a continuation of present policies can be assessed from two perspectives. First, a review can be made of impacts from supplemental water projects which have been developed under present policies. A majority of the existing storage facilities and transmission systems have contributed to recharging groundwater reservoirs. In many cases recharge resulted in mounding of groundwater which has had impacts both positive (increased groundwater supply and lower pumping lifts for wells) and negative (drainage problems and use of "free" groundwater in preference to paying for water projects). The projects have had impacts on streamflows to including reduction of flooding, depletion of flow, stabilization of flow, trapping of sediment, and changing ability of streams to scour their beds. Wetlands and habitats also have been both positively and negatively impacted. One transmission system created a hazard for wildlife movement. Projects have resulted in population stability or growth by providing opportunities for youth. They also have fostered economic growth on a regional basis and frequently on a local basis.

A second assessment of impacts can be made from a forecast of user response to a continuation of existing policies. Since the late 1950s there has been limited supplemental water development in Nebraska involving surface-water storage. Availability of funds is part of the cause for this response. The North Loup Project now under construction may be the last federally funded project without cost sharing. The intensive development of groundwater as a source of irrigation supply has reduced the "demand" for traditional surface-water projects. The declines in water level which this activity has caused have been addressed through experimental supplemental projects such as recharge wells and a reservoir with recharge as a major benefit. It is difficult to determine if experimental projects like these will become normal practices. Government policies, especially at the federal level, have aided the slowdown in construction of supplemental water projects such as in the case of the O'Neill Unit. This attitude and response must be considered as an impact of a continuation of present policies. If this scenario of very limited construction continues, there will be correspondingly limited impact from supplemental water development.

B. INTEGRATED MANAGEMENT*

* *The three following paragraphs were written by J. David Aiken, Water Law Specialist, Department of Agricultural Economics, University of Nebraska-Lincoln.*

"Conjunctive water management" means different things to different people (See Trelease, *Conjunctive Use of Groundwater and Surface Water*, 1981, Rocky Mtn.Min.L.Inst. 1853). The two general approaches to conjunctive water management are: (1) coordinating the rights to use interrelated surface and groundwater supplies, and (2) integrating the use of water from more than one source (excluding precipitation). In southern California, for example, the use of imported surface water (some of which is stored underground) is integrated with the use of local groundwater. Administratively coordinating the rights to use interrelated surface and groundwater supplies has been pioneered in Colorado, whereas integrating the use of water from

multiple sources has developed principally in California.

The Colorado approach of coordinating the rights to use interrelated groundwater and surface water supplies traditionally has meant applying the doctrine of prior appropriation to both groundwater and surface water where the groundwater is "tributary" to the stream (i.e., conveniently considered to reach the stream within a specified time if not first intercepted by a well). The basic purpose of such conjunctive management operations is to allow "junior" (i.e., subsequent in time) groundwater uses to be initiated while protecting existing "senior" (i.e., prior in time) surface water appropriators. For example, junior groundwater appropriators (who are subsequent in time and therefore subsequent in right) have been required to provide substitute water to senior surface water appropriations (who are prior in time and therefore prior in right) (1) by developing additional supplies for use as needed by senior surface appropriators, (2) by retiring senior surface appropriations by purchase, and (3) by purchasing or developing supplemental stored water or groundwater for use as needed by senior surface appropriators. This aspect of integrated water use is important to development of supplemental water supplies because it addresses the important issue of how secure the rights to the source of supplemental water are.

The availability of supplemental surface water (including Colorado river water) has led to the integrated use of imported surface water and native groundwater in southern California. This includes the use of underground storage capacity created by groundwater depletion to store imported surface water underground. California Supreme Court decisions have facilitated the evolution of these integrated-use policies by recognizing an exclusive right of groundwater recharge entities to control withdrawals of water stored underground. If rights to withdraw groundwater are judicially determined and if withdrawals are limited to each user's proportionate share of the groundwater reservoir's "safe yield," recharge entities can charge water users for groundwater withdrawn in excess of the safe yield allocation. The safe-yield adjudication process essentially establishes that any groundwater withdrawn in excess of the safe-yield allocation is recharged groundwater for which the recharge entity must be paid. In addition, "water replenishment districts" are authorized to charge "equity assessments" to encourage water users to use more expensive imported surface water in lieu of relatively less expensive groundwater by equalizing the cost of water from the two sources through water charges. The California example of developing effective institutions for integrating the use of supplemental surface water with native and recharge groundwater supplies is an important water management development.

The following discussion addresses three integrated management techniques: (1) underground water storage, (2) integrated use of water from multiple sources, and (3) water exchanges. The second management technique is followed by the alternative necessary to implement that technique and thereby to enhance the use of integrated management as a means to encourage supplemental water development. Alternatives to implement the first technique, underground water storage, were developed by the task force that prepared this report. However, passage of LB 198 by the Legislature in 1983 eliminated the need for presenting those alternatives.

1. UNDERGROUND WATER STORAGE

Water can be stored underground, either deliberately (e.g., through injection wells), or incidentally to a surface water storage project (e.g., seepage from canals and laterals and deep percolation from irrigated land). The Central Nebraska Public Power and Irrigation District ("Tri-County") is the best known Nebraska illustration of incidental groundwater storage. Given the widespread groundwater development for irrigation in

Nebraska, the existing investment in wells, and the likelihood of widespread groundwater depletion due to irrigation water use, recharging groundwater reservoirs by storing water underground is an important potential water-supply augmentation technique for Nebraska groundwater users. For individuals or organizations to deliberately engage in underground water storage activities, however, they must be given either the authority to control withdrawals of water stored underground or else some other means to charge for the use of water stored underground. This authority has been granted by LB 198.

2. INTEGRATED USE OF WATER FROM MULTIPLE SOURCES, Alternative #1 (formerly Alternative #4)

Where stored surface water, imported surface water, or imported groundwater are available to augment local

water supplies, water users have the opportunity to integrate the use of water from these multiple sources to achieve the most effective use of all supplies. For example, where groundwater depletion is occurring, supplemental water (from whatever source) can be used directly to reduce groundwater withdrawals, or can be used to recharge depleting groundwater supplies. In these circumstances supplemental water could be used for direct use during the irrigation season and then used to recharge groundwater supplies during the rest of the year. In another illustration, water users having access to both streamflow and stored surface water and/or groundwater could use streamflow whenever it is available, using supplemental water from whatever source only when necessary to supplement streamflow.

Developing supplemental water supplies is expensive. When groundwater recharge is involved, using imported supplemental water may be more expensive than using groundwater (whether recharged or not) unless withdrawal fees are established. For example, water district managers may purchase stored surface water or imported surface and/or groundwater to augment local groundwater supplies. To equalize the costs of using the less expensive groundwater and the more expensive imported/stored water, costs can be equalized by imposing a pumping charge on groundwater withdrawals and using this revenue to reduce the cost of surface water. Pumping charges may be raised to the point where groundwater and surface water cost the same, and water users have no private economic incentive to use one source to the exclusion of the other. This makes water users indifferent regarding which source they use, and users with the ability to use stored/imported water or groundwater can use water from any source depending on its availability. This also gives water suppliers the flexibility to allow customers to take water delivery in the method most convenient (and therefore, presumably, most cost effective) to the district.

ALTERNATIVE #1 (formerly Alternative #4)
Authorize water suppliers to vary surface water and groundwater use fees to achieve a balanced use of each.

Alternative #1 probably would not provide enough of the new funds which might be necessary for new projects that would incorporate the concept of integrated management. However, these alternatives might allow existing projects, or those now authorized or under construction to use integrated management as a method to supplemental water. As discussed above, some projects in Nebraska are experiencing conjunctive use without the benefit of managing it.

3. IMPACTS OF ALTERNATIVE #1

In areas of high water tables (Tri-County and Farwell Unit) integrated management could allow balancing of the source of water used with resulting reduction in lakes and wetlands, increased crop land, lowered water tables, reduced flow in drainage ditches and perennial streams and changes in the flow of source streams and storage reservoirs. In areas of declining water tables (Lodgepole Creek, and O'Neill area and elsewhere) the same balancing would occur and could result in more diversion from streams and stabilized groundwater levels and base flow in streams. These impacts would result in corresponding environmental impacts and would be similar to those experienced in the past with some possible differences in magnitude and timing.

If new fees are imposed on groundwater users, initial net returns to farmers and economic activity in the region would decrease to be offset from increased income and expenditures by water suppliers and by long-term net economic gains if the groundwater levels are stabilized. The same general economic impacts could result if fees are varied to balance the amount of use. Social impacts should not differ from those experienced under current policies except they would be positive if a stabilized groundwater level results. The exception is that negative attitudes towards new fees on groundwater could be a major social impact from the introduction of integrated management concepts. Those attitudes could hinder or kill such management attempts.

The costs to water suppliers for integrated management could be relatively large for a small district. This could limit its introduction and/or application.

4. WATER EXCHANGES

Another example of how water use can be integrated is water exchanges. A water district or individual needing water at a location where no unappropriated water is available could obtain the water presently used by someone else by developing a new source of water for that present user. For surface water, this can be done under present policy by providing storage water to downstream natural flow appropriators. The owner of the storage reservoir can then divert the water that would have gone to the natural flow appropriator (Neb. Rev. Stat., Section 46-242). If the new use involves an interbasin transfer or an intentional recharge of groundwater, present state policies relating to those types of water uses would also apply. Additional opportunities for exchanges may also be presented by recent legislation allowing water right transfers. Water exchanges involving groundwater do not appear to be authorized at present, at least not for agricultural purposes.

If they were authorized, groundwater could be pumped into the stream to supplement flows. Upstream users could then divert the surface water which is being replaced by groundwater being pumped downstream. This type of exchange would be most appropriate in those areas where the alluvium is annual-

ly recharged. In those instances, the groundwater being pumped would be much like water stored in a surface reservoir. Only the storage medium is different.

There is one other type of exchange which is beyond the scope of this report, but which nevertheless deserves brief mention. In some states where the interrelationship between ground and surface water is given greater recognition than in Nebraska, users of one source (ground water or surface water) which adversely affect senior users of the other source are required to implement water exchanges. For example, if ground water pumping is resulting in a reduction in streamflow to the detriment of senior surface appropriators, the groundwater users are required to replace the surface water by the amount of the reduction. Depending upon the physical opportunities present, such replacement may be accomplished by the same methods discussed above, i.e., new storage facilities or direct pumping of groundwater into the stream. Alternatives relating to these types of exchanges will be presented and discussed in the Surface Water/Groundwater Interrelationships study now in progress.

No separate alternatives are identified to deal with water exchanges as present policy seems adequate for exchanges involving surface water only. For those where the substitute source is to be groundwater, implementation of *Alternative #6* is adequate to authorie such exchanges to the extent considered in this report.

C. CHANGES IN WATER RIGHTS

The following alternatives propose changes in existing statutes that could encourage the development of supplemental water supplies. The first two alternatives would change groundwater rights. The third and fourth alternatives would change certain aspects of surface-water rights.

1. GROUNDWATER RIGHTS, Alternatives #2 and #3

ALTERNATIVE #2 (formerly Alternative #6)
Authorize groundwater transfer for agricultural purposes to include irrigation, recharge and surface and underground storage. This alternative also could allow the transfer of groundwater beyond overlying ground. It could include a clarification of current transfer authorization for natural resources districts and reclamation districts. Finally, the alternative could clarify the authorization for the transfer of groundwater in a stream or stream channel.

ALTERNATIVE #3 (formerly Alternative #7)
Declare that groundwater may be used to supplement natural flow to meet streamflow needs. Low flows in stream reaches that are fully appropriated at times could be augmented by pumping groundwater into the stream when necessary to prevent damage to instream values. Use of this water by other users along the stream or stream segment would be prohibited. This is discussed in detail in the Policy Issue Study on Instream Flows, page 85 (Nebraska Natural Resources Commission, 1982).

2. SURFACE-WATER RIGHTS, Alternatives #4 and #5

ALTERNATIVE #4 (formerly Alternative #8)
Remove the preference for junior natural-flow appropriators over senior storage appropriators during irrigation season. This would ensure that storage project developers could depend on water being available for storage during irrigation season. (Amendment to Neb. Rev. Stat. §46-241(2))

ALTERNATIVE #5 (formerly Alternative #9)
Develop more specific guidelines as to what is "diligent prosecution of work" necessary to extend an application for water for a supplemental water project that has not been completed. Such guidelines would be intended to prevent long and continued extensions in the holding of an unperfected water right. (Amendment to Neb. Rev. Stat. §46-238.)

3. IMPACTS OF ALTERNATIVES #2 THROUGH #5

Alternative #2 basically would authorize or legalize actions now being carried out, so impacts would change only in magnitude and timing from those now experienced from groundwater withdrawals and use. *Alternative #3* could enable projects such as habitat enhancement to proceed and might bring about funding for such a project. Impacts from such actions could include increased streamflow and increased instream

values. However, in some instances, groundwater which enters streams could introduce water-quality problems in those augmented streams. A major social impact could be public resistance to such uses for groundwater. *Alternative #4* would aid water suppliers through allowing them to maintain storage in quantities closer in size to those demands which are placed upon them. *Alternative #5* might place a priority on the aggressive developments of supplemental water projects. The impacts of these last two alternatives would not change from the impacts of present policies.

D. SOURCES OF FUNDING

Inadequate funding is a major deterrent to developing supplemental water supplies. Section F of Chapter 4 concludes that this is one of two economic factors that are potential constraints to water development. Section A of this chapter briefly recounts the previously heavy involvement of federal government in this area of funding. The comparatively small funding contributions from state and local government are pointed out in the same section. The following are changes that could be made or introduced at the state and local levels of government to increase available funds for supplemental water development.

1. STATE LEVEL FUNDING, ALTERNATIVES #6 THROUGH #12

ALTERNATIVE #6 (formerly Alternative #10)
Increase annual appropriation to the Resources Development Fund. Costs for all but the small-size supplemental water projects exceed the annual appropriations to the fund. For example: (1) Maskenthine Reservoir, capacity of 1,000 acre-feet, cost about 1 million dollars, (2) Willow Creek Reservoir, capacity of 6,600 acre-feet, will cost about 5.2 million dollars, and (3) Norden Dam and Reservoir, capacity of 415,800 acre-feet, will cost over 370 million dollars.

ALTERNATIVE #7 (formerly Alternative #11)
Designate an add-on (increase) to an existing state tax such as sales or income tax to be used for the construction of supplemental water projects.

ALTERNATIVE #8 (formerly Alternative #12)
Levy a special tax on commodities such as cigarettes or liquor to be used for supplemental water projects.

ALTERNATIVE #9 (formerly Alternative #13)
Specify that a percent of the Severance (oil and gas) Tax Fund be used for supplemental water projects. (Amendment to **Neb. Rev. Stat.** §57-705)

ALTERNATIVE #10 (formerly Alternative #14)
Implementation of the amendment to Article XIII, Section 1 of the Constitution of Nebraska by passing legislation which would allow revenue bonds to be issued for construction of water retention and impoundment structures. Repayment could be pledged by the state from revenue as derived from such structures. One form such implementation could take would be to establish a water-development finance fund which would issue tax-exempt revenue bonds thus reducing interest costs of financing. Two similar funds that now exist in Nebraska are the Nebraska Mortgage Finance Fund (Neb. Rev. Stat. §76-1603) and the Nebraska Development Finance Fund (Neb. Rev. Stat. §76-1801).

ALTERNATIVE #11 (formerly Alternative #15)
Allow the state to issue general obligation bonds with or without a referendum for development projects. (Amendment to Constitution of Nebraska, Article XIII)

ALTERNATIVE #12 (formerly Alternative #16)
Allow the state to institute water-use fees to be used as revenue to pay for supplemental water projects.

2. IMPACTS OF ALTERNATIVES #6 THROUGH #12

Increased state-level funding could result in larger and more of the types of projects being developed under present policies. The physical and environmental impacts could vary in magnitude and timing from those now being experienced. Economic impacts could be dependent on the methods of raising additional funds. If revenues from the project are the source of the funds, impacts would be similar to, but possibly of a greater magnitude than those from projects previously financed in this manner such as Tri-County. Other sources such as special taxes, general appropriations, designated taxes, etc. could result in a favorable economic impact on the project area while having an adverse economic impact on the rest of the state or the users of the commodities which are taxed such as oil, gas, liquor, etc. Social impacts would reflect this adverse economic impact through a likely resentment on the part of the users who are affected. All the alternatives could require increased administrative costs and possible institutional revisions. An increase in the number of projects could have a similar institutional impact.

3. LOCAL GOVERNMENT-LEVEL FUNDING, ALTERNATIVES #13 THROUGH #18

ALTERNATIVE #13 (formerly Alternative #17)
Allow exceptions in the Local Option Tax Control Act for increases in expenditures by local governments for supplemental water developments. (Amendment to Neb. Rev. Stat. §77-3401 et seq.)

ALTERNATIVE #14 (formerly Alternative #18)
Allow tax-increment financing by local governments for the purposes of funding the development of supplemental water projects. (Amendment to Constitution of Nebraska, Article VIII, Section 12)

ALTERNATIVE #15 (formerly Alternative #19)
Allow a general land tax on the capital gain (appreciation in the value of land) which can be attributed to an irrigation project. This tax would be applied uniformly to all land in a project area. Such a tax system would encourage irrigation or putting the land to some other form of highest use and would discourage land speculation. Such a tax would require a constitutional amendment and subsequent enabling legislation. (Viessman, Hanke, and Enevoldson, 1975).

ALTERNATIVE #16 (formerly Alternative #20)
Authorize local governments to allow water suppliers to charge a water-use fee as a method to produce revenue for providing supplemental water.

ALTERNATIVE #17 (formerly Alternative #21)
Authorize natural resources districts to levy a specific rate which only could be used by the district for planning and capital construction of supplemental water projects. (Amendment to Neb. Rev. Stat. §2-3201 et seq.)

ALTERNATIVE #18 (formerly Alternative #22)
Authorize natural resources districts with voter approval to issue general obligation bonds for capital construction costs and administrative and interest costs relating to supplemental water projects. Such legislation would provide for tax authorization to secure adequate bond repayment revenue. (Amendment to Neb. Rev. Stat. §2-3201 et seq.)

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4. IMPACTS OF ALTERNATIVES #13 THROUGH #18

Local entities, to include water suppliers, are not required to prove direct economic feasibility for supplemental water projects which they might fund. Such lack of criteria when coupled with unlimited funding could result in more and larger projects. However, local entities are limited in amounts of funds which they can raise and probably would tend to raise these funds only from those who benefit from a project. Therefore, projects probably would decrease in number and size especially if local funds were the only available source. Therefore, physical and environmental impacts would be similar to projects now being developed varying only in magnitude and timing. If the funds came from lands

that a project benefitted, the economic impact would be direct, net economic benefits either in the short-term or in the long-run provided the project had a positive cost-benefit ratio. If the funds came from all property owners the impact could be negative, direct, net economic benefit and positive, indirect economic benefits or other impacts depending upon the project. Social impacts also would reflect this dichotomy in source of funding. Funds from the benefitted area could result in positive social impacts such as increases in business volume, employment, personal income, etc. These increases might be stabilized only if the project was to preserve a groundwater reservoir. Funds from general taxes could cause resentment and opposition which might surface in legal and political activity which would delay developments. If the funding was used for long distance transfers there could be extremely negative social impacts in the losing areas. Institutional impacts could include increased administrative cost to local governments.

E. CHANGES IN EXISTING PROGRAMS

In the 1970s the State of Nebraska authorized three programs which have potential as now established to assist in the development of supplemental water supplies. These are the Resources Development Fund, Water Conservation Fund (renamed the Soil and Water Conservation Fund by LB 236, passed during the 1983 legislative session), and State Water Planning and Review Process. The following proposed changes could enhance the development capabilities of the programs. A common change that would enable all three programs to aid in the development of more supplemental projects is an increase in their funding above current levels. The source for this could be some of revenue sources that were proposed in Section D of this chapter. In addition, this chapter looks at two other alternatives — one a proposal to give priority to joint-use structures and another that would affect local governmental taxing bodies.

1. RESOURCES DEVELOPMENT FUND, ALTERNATIVES #19 THROUGH #22

This program was established by state legislation in 1974. It was originally proposed as part of the State Water Plan by the Nebraska Natural Resources Commission in 1972. The following changes would allow the fund to better aid in the development of supplemental water supplies.

ALTERNATIVE #19 (formerly Alternative #23)
For purposes of the Resources Development Fund, establish economic feasibility so that a supplemental water project would not have to meet the criteria that its costs do not exceed its primary and tangible benefits. For instance, secondary benefits could be considered as well. This change could be done by the Natural Resources Commission and the Development Fund Advisory Board (change Rule 1-(2)(n), Guidelines, Nebraska Resources Development Fund , or it could be mandated by the Nebraska Legislature. (Amendment to Neb. Rev. Stat. §2-3263 et seq.)

ALTERNATIVE #20 (formerly Alternative #24)
Allow Resources Development Fund grants to be used for supplemental water projects that produce revenue. (Amendment to Neb. Rev. Stat. §2-3266).

The Natural Resources Commission could set the following priorities for projects to be funded:

ALTERNATIVE #21 (formerly Alternative #25)
Projects that include the development of large-size storage facilities would be given preference in the Resources Development Fund.

ALTERNATIVE #22 (formerly Alternative #26)
Projects which can physically include integrated management as a purpose would be given preference in the Resources Development Fund. This would require developing a clear method of assessing benefits from groundwater recharge and other aspects of integrated management.

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2. IMPACTS OF ALTERNATIVES #19 THROUGH #22

The physical and environmental impacts would depend on how these program changes were combined with other alternatives. Economic impacts would probably include positive benefits in the project area at the expense of the state as a whole. Generally, there would be a shift in costs for the project from the direct beneficiaries to the indirect beneficiaries and those who

do not benefit. The social impact would be a greater redistribution of taxes to project beneficiaries with the possible negative public attitudes to such actions by government. *Alternatives #19* and *#20* would probably reduce the work of processing applications. *Alternative #22* could increase this work.

3. WATER CONSERVATION FUND, ALTERNATIVE #23

Although this fund was not established to help with major water-development construction, certain changes in it would assist in supplemental water supplies development.

ALTERNATIVE #23 (formerly Alternative #27)
In administering the Nebraska Soil and Water Conservation Fund, the Natural Resources Commission could require that natural resource districts place a priority on projects and practices to be funded which would offset the need for supplemental water supply by improving groundwater recharge potential. This change could also be mandated by the Nebraska Legislation. (Amendment to Neb. Rev. Stat. §2-1579)

4. IMPACTS OF ALTERNATIVE #23

Impacts from this change would be similar to those impacts now felt from the program. If the changes promoted increased recharge, the physical and environmental impacts would increase in magnitude only. The economic impacts would continue to be felt by the individual landowner who benefits from the program. Landowners who would have received funds before the program changes were made may receive the negative impact of less funds.

5. STATE WATER PLANNING AND REVIEW PROCESS, ALTERNATIVE #24

The legislation for this program authorizes the state through the Natural Resources Commission (NRC) to plan and design water resources projects (**Neb. Rev. Stat.** §2-3282).

ALTERNATIVE #24 (formerly Alternative #29)
Direct through legislative intent that NRC implement this portion of the legislation and provide specific appropriations to NRC for this purpose.

6. IMPACTS OF ALTERNATIVE #24

A majority of the impacts from this alternative would depend on the types of projects undertaken. However, this alternative clearly would increase the NRC work load and possibly the work load of advisory and regulatory agencies such as the Department of Water Resources.

7. JOINT-USE STRUCTURES, ALTERNATIVE #25

There now exist in the state ten or twelve joint-use structures on state road where a water impoundment structure is also used as a stream-crossing road structure. This requires a sharing of the construction costs by the road-building and water-development entities. A major impediment to this program has been the timing of availability of funds by one of the other entities. This problem could be overcome by both entities giving equal priority to such joint-use structures.

ALTERNATIVE #25 (formerly Alternative #30)
Strengthen the policy of the State Engineer (Director, Nebraska Department of Roads) to construct road structures which can be incorporated into the design of water impoundment structures.

8. IMPACTS OF ALTERNATIVE #25

This alternative could result in the construction of more joint-use structures. The impacts would be similar to those from the existing program except in magnitude and timing. There could be administrative impacts of increased work loads for both the road-building and water-development entities.

9. IN LIEU OF TAXES, ALTERNATIVE #26

ALTERNATIVE #26 (formerly Alternative #31) Authorize local governments to collect payments in lieu of taxes for land which is used by the construction of supplemental water projects. The amount of these payments in lieu of taxes could be adjusted in accordance with property assessments as required by the Nebraska Department of Revenue. This would require an amendment to Neb. Rev. Stat 70-651.01 for public power districts and a constitutional amendment and new legislation for other water project development entities.

10. IMPACTS OF ALTERNATIVE #26

Although this alternative might appear to discourage the development of supplemental water projects, it could reduce opposition to the projects by local governmental taxing units whose only impact from the project would be a loss of income-producing property.

11. MODIFY NON-GAME AND ENDANGERED SPECIES ACT, ALTERNATIVE #27

ALTERNATIVE #27 (new alternative)
Amend Section 37-435(3) and other sections of the Non-Game and Endangered Species Act so that the state act includes an exemption process and is otherwise consistent with the federal act.

When enacted, the present Nebraska Endangered Species Act was essentially copied from the federal law as it existed at that time. In 1978, the federal act was modified to include an exemption procedure. That procedure utilizes a cabinet level committee to determine whether an exemption would be appropriate in any particular instance being considered. The exemption can be granted if the committee is satisfied that the consultation procedure has proceeded in good faith and if it makes the following additional findings of fact:

(i) There are no reasonable and prudent alternatives to the proposed action;
(ii) The benefits of such action clearly outweigh the benefits of alternative courses of action consistent with conserving the species or its critical habitat, and such action is in the public interest;
(iii) The action is of regional or national significance; and
(iv) Neither the federal agency concerned nor the exemption applicant made any irreversable or irretrievable commitment of resources which would prevent the formulation of any reasonable and prudent alternatives.

In the federal procedure the committee must also find that the plan of action includes such reasonable mitigation and enhancement measures as are necessary and appropriate to minimize the adverse effects of the proposed action upon the endangered species, threatened species, or critical habitat concerned.

Implementation of this alternative would require an adaptation of the federal procedure to fit the Nebraska Act. The exemption committee could be chaired by the Governor with membership from the Department of Water Resources, the Natural Resources Commission, the Game and Parks Commission, and the Department of Environmental Control.

12. IMPACTS OF ALTERNATIVE #27

This alternative could result in an increase in development of supplemental water projects, especially if the exemption procedure was used in situations where the threatened or endangered species of concern was designated only under Nebraska law and not under Federal law. If federal threatened or endangered species were involved and federal action authorizing (such as through the 404 program), funding, or carrying out the conflicting project were required, the Federal Endangered Species Act would continue to apply and a federal exemption would also have to be obtained. To the extent that the exemption procedure would be utilized, a specific impact would be loss and/or modification of some habitat which is considered critical to the continued existence of whatever endangered species are involved.

F. NEW PROGRAMS

1. MISSOURI RIVER PLAN, ALTERNATIVE #28

A variety of both consumptive and non-consumptive use proposals have been made for supplemental water projects in Nebraska which could use Missouri River water.

ALTERNATIVE #28 (formerly Alternative #32)
Direct some entity to develop a plan to obtain and use supplemental water from the Missouri River.

2. IMPACTS OF ALTERNATIVE #28

The impacts of the development of a plan would depend on its final content and scope. Since such a plan could lead to a compact or decree for the river, there could be a major legal impact. This potential is discussed in the *Policy Issue Study on Selected Water Rights Report #6, Interstate Water Uses and Conflicts.* (Nebraska Natural Resources Commission, 1982).

3. PUBLIC WORKS PROGRAM, ALTERNATIVE #29

A variety of states have established state public works programs. In the 1930s they were used as a vehicle for the federal public works dollars. In California state funds were added to the program. These programs become employers of the unemployed. More recent public works programs have channeled money to private contractors for construction projects. In both Alaska and California state funds have been used for this type of program exclusively for water-related public works projects.

ALTERNATIVE #29 (formerly Alternative #33)
Institute and fund a type of public works program that would relieve unemployment and develop supplemental water-supply projects.

4. IMPACTS OF ALTERNATIVE #29

This alternative could accelerate and increase construction of supplemental water projects. Impacts therefore would differ from those previously discussed in this chapter only by magnitude and in timing. These impacts also would be dependent on what policies, programs and previous alternatives might be used in the planning and design of the projects.

5. ADVOCACY AGENCY, ALTERNATIVE #30

The most successful capital improvement programs at the state and federal levels have been those with strong, governmental advocacy agencies that can plan, construct and operate capital facilities with funds that are designated for that program from a specific source. Nationwide highway construction has been and continues as an example of this type of program through state and local highway advocacy agencies. In Nebraska the Department of Aeronautics serves as an advocacy agency which has planned, designed, and constructed an excellent statewide airport system. The economic feasibility criteria for both of these programs is different than the cost/benefit criteria that is currently required at the federal and state levels for water-development projects. Further, both programs require that the direct beneficiary pays the majority of the cost for capital improvements. Two requirements for the success of such agencies seem to be that they are under executive control (in Nebraska a code agency) and that they have dedicated funds to accomplish their capital construction. Such an agency for water development is the California Department of Water Resources.

ALTERNATIVE #30 (formerly Alternative #34)
establish a water development advocacy agency in Nebraska. This would require the Nebraska Legislature to create such an agency or significantly "overhaul" an existing agency.

6. IMPACTS OF ALTERNATIVE #30

Since this alternative could only be realized from a commitment by the Nebraska Legislature to supplemental water development which would require backing in both policy and funding, it should result in a significant increase in the development of supplemental water projects. As in *Alternative #33* above, the impacts of that increase would be changes in magnitude and timing. Other impacts would be dependent on the policies, programs and alternatives selected by the advocacy agency.

G. COMBINING ALTERNATIVES

A combination of some of these thirty-four alternatives may be the best way to significantly increase the development of supplemental water supplies in Nebraska. A continuation of existing policies without an increase in funding probably would result in developments that are very limited in quantity, size and impact. The new and amended policies and programs listed as alternatives also would require increased funding to be both accomplished and effective.

The significant development of the state's groundwater resources in recent years suggests a need for seriously considering the alternatives dealing with integrated management. Supplemental water development would be hindered without this occurring. Other alternatives would have a lessened impact without this "tool" being legally available.

The wide range of alternatives as presented in this chapter need to be examined in total and adopted in combinations if they are to have significant impact on supplemental water development in Nebraska. An example would be the creation of an advocacy agency for water development with a priority on supplemental projects. The agency could be given revenue bonding powers and the authority to collect water-use taxes. Integrated management legislation could be passed to give the new agency maximum flexibility in developing supplemental water projects. A major program of the agency could be a state-level public works program which could vitalize the construction industry.

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POLICY ISSUE STUDY
ON
SUPPLEMENTAL WATER SUPPLIES

STATE WATER PLANNING AND REVIEW PROCESS

AN APPENDIX TO
THE SUPPLEMENTAL WATER SUPPLIES
POLICY ISSUE STUDY
APPENDIX A THROUGH G

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APPENDIX A

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APPENDIX A
WATER SUPPLIES IN NEBRASKA STREAMS

I. DERIVATION OF SURFACE WATER SUPPLY TABLES

The tables presented in the appendix for each major basin in Nebraska include both measured and estimated values. The water yield is a 10-year average of gaged flow for a given sub-basin. The range of the water yield is simply the maximum and minimum gaged flow for the ten water years 1969-1978. The consumption was calculated for each sub-basin as the difference between measured diversions and returns, or as the product of acres irrigated from surface water sources and the estimated average consumptive use. The latter method was used to calculate consumption in basins lacking gaged diversions and returns. The gross supply for a sub-basin is simply the sum of the measured sub-basin water yield and the consumption. These values are defined in terms of the table headings (SUB-BASIN, SUPPLY, CONSUMPTION, WATER YIELD, and RANGE OF WATER YIELD) in greater detail as follows.

1. SUB-BASIN:
A SUB-BASIN, for the purpose of this study, is a fraction of a basin for which the WATER YIELD is defined by one or more stream gages. A SUB-BASIN in the headwaters region of a basin is gaged at the furthest downstream point of the highest order stream. A SUB-BASIN farther downstream in the basin is bounded by inflow gages on upstream tributaries and a downstream gage on the main channel draining the area.

2. SUPPLY:
The gross SUPPLY was computed by adding the net or measured WATER YIELD to the CONSUMPTION. This was done, as the gross basin surface water supply would include both the total gaged basin outflow and the surface water used upstream of the gage. Additional losses such as evaporation were not evaluated, as they are not a potential component of usable supply.

3. CONSUMPTION:
The CONSUMPTION figure was computed by subtracting the measured returns from the measured diversions, where gaged data was available. In those basins where diversions and returns are not gaged, the CONSUMPTION was estimated. The estimated CONSUMPTION was computed as the product of the acreage irrigated from surface water times the estimated consumptive water use per acre. The acreage was obtained from the Department of Water Resources (DWR) Biennial Report and the results of cancellation hearings, and the consumptive use was estimated using data from a variety of sources, including the observations of DWR employees serving the basins involved.

4. WATER YIELD:
This figure is the average gaged reach discharge for the ten water years 1969 through 1978. The water yield between gages was computed by subtracting the reach inflow from the reach outflow. In some SUB-BASINS, this method results in a negative WATER YIELD. A negative water yield indicates that demands for that fraction of the basin were met by a reduction in WATER YIELD upstream. This means that a positive WATER YIELD in the upper fractions of the basin or in the SUB-BASINs may already be committed to use in lower SUB-BASINs and may not be available for use farther downstream. Basins and SUB-BASINs in which this may occur are described in detail in the following text.

5. RANGE OF WATER YIELD:
This number was also derived from the 10-year gaging record. The minimum figure was the smallest computed annual reach gain for the 10-year period and the maximum figure was the largest computed reach gain for that period.

II. WATER SUPPLIES IN THE WHITE, HAT AND WHITE CLAY BASINS

The rivers and streams of the Northwestern Panhandle have their origins in the rugged and scenic Pine Ridge country. Each of the three major waterways begin as narrow, swiftly flowing streams, which spill from steep canyons onto grass-covered plains and roll-

ing hills. Nearly all of the flow in the streams originates in the upland headwaters. As the channels meander through the clay and calcareous soils of the grasslands near the South Dakota border, the total flow is reduced by evaporation, seepage to the water table, and diversions for irrigation. Hat Creek, in particular, is subject to large losses as it flows from the base of the Pine Ridge formation to the South Dakota border. The White River possesses the largest and most consistent water supply of the rivers and streams in the region, due to the network of upland tributaries which feed the main stem along its entire length in Nebraska.

Due to the aridity of the region, the maximum variation of the supplemental water supply ranged from 11 to 350 percent of the ten-year average. Table A-1 provides a summary of the surface water supply, consumption, and the remaining water yield for the region.

Hat Creek. This basin is the most westerly and arid of the watersheds of the region. As a result of the wide variation in flow on Hat Creek, irrigation development is severely limited. During dry years, essentially no water is available to fill the system of shallow canals that water the irrigated pastures. Even during wet years, little flow is available, during the summer, in the grasslands region downstream of the Pine Ridge formation.

White River above Crawford. The White River in this sub-basin has a small, but dependable, supply of high quality water during even the driest years. As indicated by Table A-1, there is little variation in flow at Crawford, from year to year, despite wide variations in climate. This steady supply is a result of the nearly constant flow of groundwater from springs in the deep canyons of the Pine Ridge.

TABLE A-1

SURFACE-WATER SUPPLIES WHITE, HAT AND WHITE CLAY BASIN

AVERAGE ANNUAL QUANTITIES IN ACRE FEET (1969-78)

SUB-BASIN	SUPPLY	CONSUMPTION*	WATER YIELD	RANGE OF WATER YIELD
Hat Creek	2,760	150	2,610	290 — 9,110
White River above Crawford**	15,530	1,310	14,230	12,590 — 15,190
White River, State Line to Crawford**	29,360	4,590	24,770	5,510 — 39,810
White Clay Creek to State Line	3,770	40	3,730	1,910 — 5,000

* EXCLUDES EVAPORATION
** INCLUDES MUNICIPAL USE

Source: Nebraska Department of Water Resources October 1980

White River State Line to Crawford. The portion of the White River draining the rolling grasslands of Northern Dawes County is subject to far more variation in mean annual flow than the region upstream. Annual water yield from this sub-basin may vary by nearly an order of magnitude from year to year. Some irrigation is practiced in the river bottoms and associated terraces within the region. At the present level of development, water supplies are generally sufficient to meet the needs of the irrigators; however, scattered shortages of stock water have been reported, from time-to-time, along some of the tributaries in the sub-basin.

White Clay Creek. Due to the limitations created by poor soil conditions, the development of irrigated agriculture in the basin has been quite small. On an average annual basis, the supply of water greatly exceeds the amount consumed. Due to the small size of the basin, however, the quantity of unused water in the watershed is minimal.

III. WATER SUPPLIES IN THE NIOBRARA RIVER BASIN

Table A-2 summarizes surface water supply, consumption and the remaining water yield within the Niobrara River basin of Nebraska. The table segregates the basin into major sub-basins. The main stem sub-basin is separated at the Gordon gaging station into two parts. The majority of water-resources development from the Niobrara River itself is located upstream of Gordon. Quantities shown for the two main stem sub-basin segments are exclusive of tributary contributions and represent sub-basin yield.

Data used in preparation of Table A-2 was compiled from estimates and from published records of pump and canal diversions, stream gaging stations and reservoir stations. The quantities listed are the average annual renewable supply of each sub-basin. The amounts were computed from data collected during the ten-year period 1969-1978.

In the Keya Paha sub-basin, maximum variation of the water yield ranged from 40 percent to 185 percent of the ten-year average. The range in all other sub-basins was considerably less.

IV. WATER SUPPLIES IN THE BASINS OF NORTHEAST NEBRASKA WHICH DRAIN DIRECTLY INTO THE MISSOURI RIVER

The Missouri River tributary streams of northeast Nebraska drain watersheds which are characterized by steep slopes and narrow wooded valleys. As a result of the rugged terrain flanking the upland channels, only a small portion of each basin may be easily irrigated using water from the streams. Due to the small size of many of the basins, and the absence of streamflow and water-use data on the majority of the small tributaries, only five basins are listed. The greatest variation of the water yield was the range of 17 to 220 percent of the ten-year average which was recorded on the Ponca Creek Basin. The range of annual flow in all of the other basins was considerably less. Table A-3 provides a summary of the surface water supply, consumption, and the remaining water yield for the region.

TABLE A-2

SURFACE-WATER SUPPLIES NIOBRARA RIVER BASIN

AVERAGE ANNUAL QUANTITIES IN ACRE FEET (1969-78)

SUB-BASIN	SUPPLY	CONSUMPTION	WATER YIELD	RANGE OF WATER YIELD
Main Stem Niobrara from Stateline to Gordon	90,670	14,990	75,680	67,530 — 84,650
Snake River	129,250	31,080	98,170	74,920 — 119,800
Minnechaduza Creek	22,420	400**	22,020	15,220 — 30,100
Plum Creek	79,860	180**	79,680	67,030 — 93,680
Long Pine Creek	104,320	80**	104,240	91,620 — 119,500
Keya Paha River	81,690	980**	80,710	32,320 — 149,400
Main Stem Niobrara from Gordon to Mouth	616,620	6,000**	610,620	535,060 — 694,410

* EXCLUDES EVAPORATION
** ESTIMATED

Source: Nebraska Department of Water Resources July 1980

TABLE A-3

SURFACE-WATER SUPPLIES IN THE BASINS OF NORTHEAST NEBRASKA WHICH DRAIN DIRECTLY INTO THE MISSOURI RIVER

AVERAGE ANNUAL QUANTITIES IN ACRE FEET (1969-78)

	SUPPLY	CONSUMPTION	WATER YIELD	RANGE OF WATER YIELD
Ponca Creek	47,335	135	47,200	8,250 — 104,000
Bazile Creek	48,690	600	48,090	31,720 — 81,730
Omaha Creek	25,065	125	24,940	7,800 — 54,680
Tekamah Creek	4,575	85	4,490	1,080 — 8,810
Papillion Creek	116,810	715	116,100	53,182 — 205,858

* EXCLUDES EVAPORATION Source: Department of Water Resources October 1980

Ponca Creek. Ponca Creek rises in South Dakota and enters the Missouri River upstream from the mouth of the Niobrara. The portion of the stream between the state line and the Missouri River is deeply incised into the rolling uplands of northern Nebraska. In many places, the stream has cut into the underlying Pierre Shale which forms the bedrock of the region. Although the average annual flow greatly exceeds the quantity used for irrigation, there have been many extended periods during drought years in which the stream has gone completely dry.

Bazile Creek. Bazile Creek has a relatively steady water supply in comparison to Ponca Creek. Although the annual flow in the stream always exceeds the demand for irrigation water, the stream has gone dry near the mouth for short periods during drought years. Even during the times when the lower reaches of the stream have gone dry, some flow has been present in the upland tributaries which drain the Ogallala Aquifer with springs and seeps.

Omaha Creek. This stream drains a region which is characterized by rolling loess hills and wooded valleys. A small amount of land is irrigated from Omaha Creek, with wells providing the bulk of the irrigation water used in the basin. According to the records which have been kept since October 1945, the stream has never gone dry near the mouth, but flows have fallen below 1,000 gallons per minute on numerous occasions during the growing season.

Tekamah Creek. Tekamah Creek is the smallest of the streams in this region for which accurate long-term records have been maintained. This stream typifies the small creeks which drain the hill lands along the Missouri River. The average annual discharge of Tekamah Creek exceeds the surface water demand by a factor of more than fifty, yet little water is available during the crucial water-short periods of dry summers.

Papillion Creek. This stream is by far the largest of the Missouri River tributaries of northeastern and east-central Nebraska. The agriculture of the basin is primarily dryland in nature, with only minor irrigation development in the lowlands. Even during dry years, irrigation demand typically amounts to less than one-sixtieth of the total annual flow. The major factor which distinguishes this watershed from others in the region is the degree of urbanization which exists near the mouth. Although the Papillion Creek system has not been subject to serious shortages of irrigation water, the quality of the water in the lower reaches has been a definite problem in recent years.

V. WATER SUPPLIES IN THE LOUP RIVER BASIN

Table A-4 summarizes surface water supply, consumption and the remaining water yield within the Loup River basin. The table segregates the basin into major sub-basins. (See also Figure A-1 for a diagram of this basin.) The main stem sub-basin extends from the confluence of the Middle Loup and North Loup downstream to the mouth. Quantities shown for that sub-basin are exclusive of tributary contributions and represent sub-basin yield.

TABLE A-4

SURFACE-WATER SUPPLIES
LOUP RIVER BASIN

AVERAGE ANNUAL QUANTITIES IN ACRE FEET (1969-78)

SUB-BASIN	SUPPLY	CONSUMPTION	WATER YIELD	RANGE OF WATER YIELD
Beaver Creek	81,570	2,470**	79,100	50,420 — 115,400
Mud Creek	23,750	720	23,030	13,280 — 46,090
South Loup River	160,580	1,100	159,480	128,170 — 233,890
North Loup River	672,920	28,370	644,550	559,140 — 700,750
Middle Loup River	803,870	91,730	721,150	524,790 — 759,420
Cedar River	162,790	1,870	160,920	130,620 — 205,240
Main Stem Loup River	(-)131,890	1,840	(-)133,730	(-)239,360 — (-)74,750

* EXCLUDES EVAPORATION
** ESTIMATED

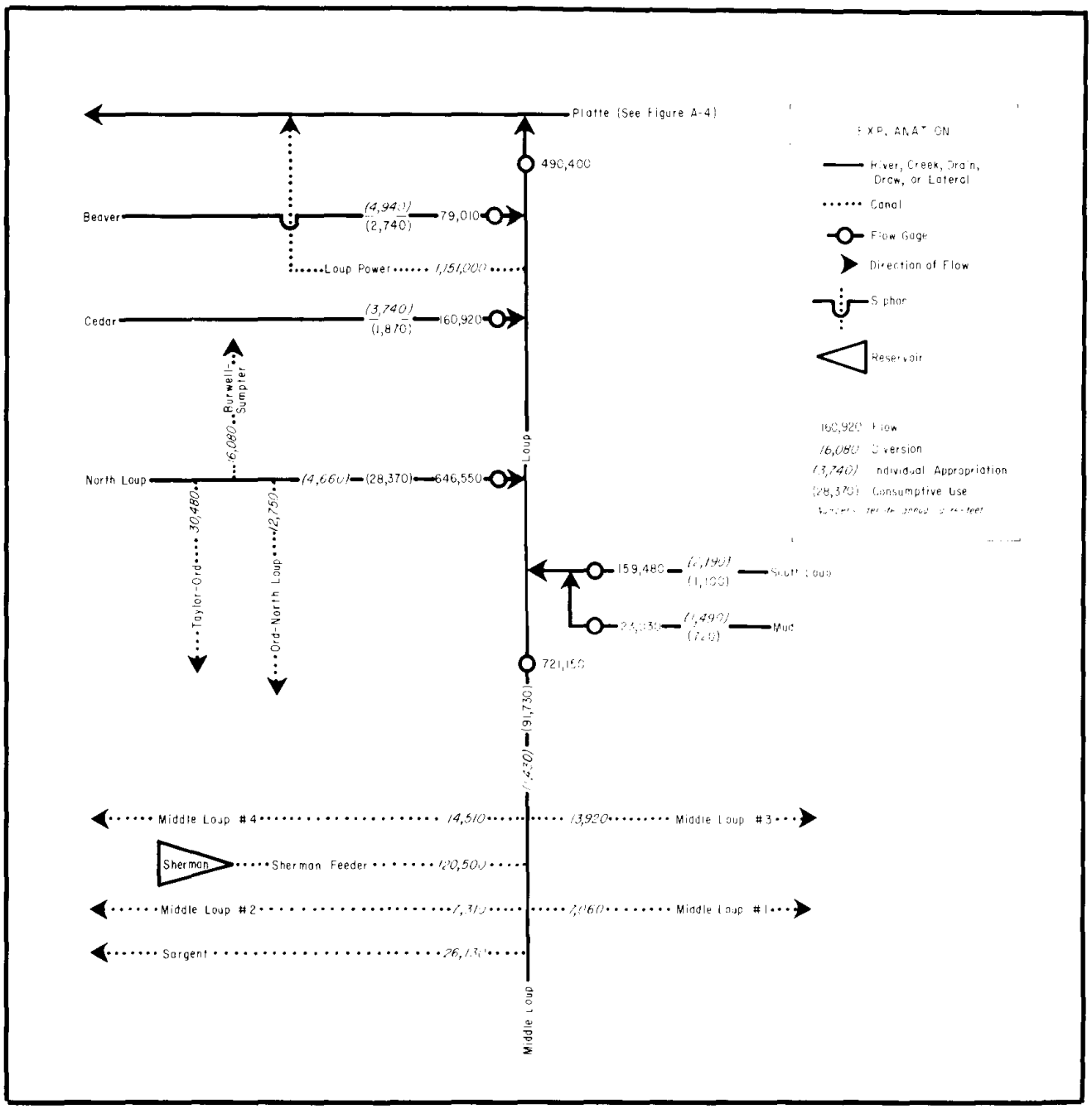
Source: Department of Water Resources July 1980

Data used in preparation of Table A-4 was compiled from estimates and from unpublished records of pump diversions having priority dates junior to September 15, 1932. Additional published data for canal diversions, stream gaging stations and reservoir contents were also utilized. The quantities listed are the average annual renewable supply of each sub-basin. The amounts were computed from data collected during the ten-year period 1969-1978.

Maximum variation of the water yield ranged from 36 percent to 200 percent of the ten-year average. The range within most sub-basins was considerably less. The negative quantity found in the supply column for the main stem is indicative of a loss in flow through the reach between St. Paul and Genoa. The algebraic sign is subsequently carried forward to the column identified as water yield. It can be interpreted that water demands from the main stem are primarily supplied by tributary inflows.

VI. WATER SUPPLIES IN THE ELKHORN RIVER BASIN

The entire Elkhorn Basin is normally blessed with a surplus of water yield over and above the quantity consumed. However, water shortages do occur, particularly in the lower portion of the basin, as a result of the seasonal distribution of streamflow. As a result, some sub-basins vary from regions of abundant water supply during the spring, to areas requiring water supply augmentation during the irrigation season. Since the Elkhorn River rises in the semi-arid Sandhills, and joins the Platte River in the more humid loess hills regions of eastern Nebraska, there is considerable variation in streamflow characteristics within the basin. Table A-5 summarizes surface water supply for this basin.



FIGURES A-1

DIAGRAM OF THE LOUP RIVER AND DRAINAGE BASIN FROM ORIGIN TO PLATTE RIVER

Note: North is generally to the left of this diagram.

TABLE A-5

SURFACE-WATER SUPPLIES
ELKHORN RIVER BASIN

AVERAGE ANNUAL QUANTITIES IN ACRE FEET (1969-78)

SUB-BASIN	SUPPLY	CONSUMPTION	WATER YIELD	RANGE OF WATER YIELD
Elkhorn River above Norfolk	286,080	4,080	282,000	207,800 — 401,200
North Fork of the Elkhorn River	55,355	1,125	54,230	25,140 — 108,800
Logan Creek	116,750	2,450	114,300	51,740 — 197,400
Maple Creek	32,775	75	32,700	9,690 — 49,600
Elkhorn River, Mouth to Norfolk**	321,985	5,870	316,115	145,930 — 587,530

* EXCLUDES EVAPORATION
** INCLUDES
a. Bell Creek
b. Pebble Creek
c. Plum Creek
d. Rawhide Creek
e. Union Creek
f. Miscellaneous Minor Tributaries

Source: Department of Water Resources October 1980

Elkhorn River above Norfolk. The uppermost portion of the sub-basin rises in an area characterized by sandy soils and high infiltration rates. The annual variation in water yield within this sub-basin is much less than may be found in other parts of the Elkhorn Watershed. This stability results from the steady base flow originating in the Sandhills. On the average, surface water consumption amounts to only about one percent of the total flow, and no major water shortages have been reported in recent years. The portion of the Elkhorn Basin above Norfolk could definitely be defined as a surface water source.

Elkhorn River, Mouth to Norfolk. The portion of the Elkhorn Watershed downstream from Norfolk lies primarily within the loess hills region of eastern Nebraska, and is thus subject to considerable fluctuation in discharge, both seasonally and annually. Unlike the Sandhills portion of the basin, the water yield in the lower Elkhorn Sub-Basin is heavily dependent upon surface runoff, and follows short-term fluctuations in climate. Water use in this sub-basin represents only a tiny fraction of the total water supply. Seasonal water shortages do occur from time to time on some of the tributaries such as Bell Creek. The sub-basin, taken as a whole, could be defined as a surface water source, although some of the tributary watersheds are regions which could be characterized as receptive areas during dry summers.

North Fork of the Elkhorn River. This sub-basin is quite similar to the Lower Elkhorn Region in flow characteristics, with annual flow varying widely over the period studied. Average annual water use ranges from about 1 to 4 percent of the total annual flow, with no major water shortages occurring in recent years. The north fork of the Elkhorn River can be considered to be a minor surface water source.

Logan Creek. This sub-basin is characterized by a wide range in flow from season to season and from year to year. The basin lies entirely within the loess hills region and is heavily dependent upon surface runoff as a source of flow. Average water use ranges from 2 to 4 percent of the total water yield on an annual basis, but some portions of the sub-basin have been known to have a deficient supply during drought years. Storage reservoirs, and agricultural practices that enhance infiltration and soil moisture storage, could provide supplemental water for use within the basin, but the amount left over for supplementing the water supply of other regions would not be significant during a prolonged drought. Logan Creek can be considered to be marginal surface water source.

Maple Creek. This sub-basin typifies the smaller tributary watersheds within the Lower Elkhorn Basin. The flow within this region has the greatest variability of any of the Elkhorn Sub-Basins. As the runoff from the surrounding loess hills provides most of the discharge, streamflow ranges from a trickle to damaging floods. Although consumption amounts to only a fraction of the total flow, Maple Creek has been critically short of irrigation water on several occasions. The water supply in this basin could be supplemented internally through the use of storage reservoirs and improved agricultural methods. This sub-basin may not be considered to be a source of supplemental water supply for use outside of the basin.

VII. WATER SUPPLIES IN THE PLATTE RIVER BASIN

Table A-6 summarizes surface water supply, consumption and the remaining water yield within the Platte River basin of Nebraska. The table segregates the basin into major sub-basins. (See also Figures A-2, A-3, and A-4 for a diagram of this basin.) The main stem Platte River sub-basin is separated into two parts. The Odessa gaging station was chosen as the hinge point since it essentially marks the eastern terminus of significant water-resources development. Quantities shown for the North Platte, South Platte, and each Platte River sub-basin are exclusive of tributary contributions and represent sub-basin yield.

TABLE A-6
SURFACE-WATER SUPPLIES PLATTE RIVER BASIN
AVERAGE ANNUAL QUANTITIES IN ACRE FEET (1969-70)

SUB-BASIN	SUPPLY	CONSUMPTION	WATER YIELD	RANGE OF WATER YIELD
Horse Creek	68,990	100**	68,890	42,780 — 93,370
Sheep Creek	56,740	11,160	45,580	39,000 — 50,750
Dry Spotted Tail Creek	29,000	1,580	27,420	18,370 — 36,080
Wet Spotted Tail Creek	11,740	3,020	8,720	6,620 — 10,080
Tub Springs	34,590	4,280	30,310	26,280 — 32,610
Winters Creek	43,130	5,150	37,980	34,570 — 44,600
Gering Drain	46,670	0	46,670	35,290 — 54,410
Ninemile Drain	93,340	0	93,340	87,200 — 98,590
Bayard Sugar Factory Drain	21,230	3,810	17,403	12,030 — 20,670
Red Willow Creek	83,000	5,850	77,150	64,240 — 87,010
Pumpkinseed Creek	18,110	4,610**	13,500	8,700 — 17,710
Blue Creek	57,740	9,230	48,510	46,100 — 52,250
Birdwood Creek	112,450	3,730	108,720	105,500 — 123,300
Bald Drain	10,220	0	10,220	5,680 — 20,500
Cleveland Drain	5,260	0	5,260	3,830 — 7,210
DeGraw Drain	3,860	0	3,860	3,260 — 4,210
Upper Dugout Creek	11,110	0	11,100	9,000 — 13,520
Fairfield Seep	1,940	0	1,940	940 — 3,450
Fanning Seep	870	0	870	0 — 3,390
Indian Creek	10,890	0	10,890	7,880 — 12,350
Lane Drain	1,680	0	1,680	1,280 — 1,990
Melbeta Drain	4,290	0	4,290	4,010 — 5,070
Scottsbluff Drain No.1	2,870	0	2,870	2,110 — 3,790
Scottsbluff Drain No.2	3,350	0	3,350	2,020 — 4,890
Main Stem North Platte River	127,780	614,480***	(-)486,700	(-)592,700 — (-)355,200

(Table A-6 continued on following page)

(Table A-6 continued from previous page)

SUB-BASIN	SUPPLY	CONSUMPTION	WATER YIELD	RANGE OF WATER YIELD
Lodgepole Creek	4,610	2,000**	2,610	0 - 7,340
Mainstream Stem South Platte River	130,010	11,210	118,800	5,060 - 306,200
Main Stem Platte River North Platte - Odessa	76,490	257,670	(-)181,180	(-)313,360 - (-) 14,820
Salt Creek	347,450	2,450	345,000	135,000 - 680,000
Shell Creek	25,490	30**	25,460	9,600 - 55,760
Main Stem Platte River Odessa - Mouth	773,840	500**	773,340	(-) 81,990 - 1,356,900

* EXCLUDES EVAPORATION
** ESTIMATED
*** INCLUDES AKERS DRAW, ALLIANCE DRAW, CEDAR CREEK, LINCOLN COUNTRY DRAIN NO. 1 AND MORRILL DRAIN

Source: Department of Water Resources August 1980

Data used in preparation of Table A-6 was compiled from published and unpublished data for gaging stations, canal and pump diversions and reservoir storage. The quantities listed are the average annual renewable native supply of each sub-basin. The amounts were computed from data collected by federal, state, and local agencies during the ten-year period 1969-1978.

Maximum variation of the water yield ranged from 0 percent to 390 percent of the ten-year average. The range within most sub-basins was considerably less. Negative quantities (found in the water yield column for several sub-basins) indicate conditions where in-sub-basin supply was insufficient to satisfy demand. Hence, tributary and out-of-state inflows fulfilled the needs of those sub-basin users.

Water impounded in Glendo Reservoir, located in east-central Wyoming, is a potential source of supplemental water. Under the decree in Nebraska v Wyoming 345 U.S. 981 (1953) 25,000 acre-feet annually is allocated to Nebraska users. This entire quantity is either contracted for, or is pending contract approval by Nebraska irrigation users. Notwithstanding these commitments, an average annual 5,080 acre-feet was delivered out of storage during the 1969-1978 period. Thus, perhaps as much as 20,000 acre-feet might be available if present contracting users agreed to modification of their agreements.

VIII. WATER SUPPLIES IN THE REPUBLICAN RIVER BASIN

Table A-7 summarizes surface-water supply, consumption and the remaining water yield within the Republican River basin of Nebraska. The table segregates the basin into major sub-basins. (See also Figure A-5 for a diagram of this basin.) It should be noted that the North Fork and the main stem are shown as a single sub-basin. For that sub-basin, quantities tabulated are exclusive of tributary contributions and represent sub-basin yield.

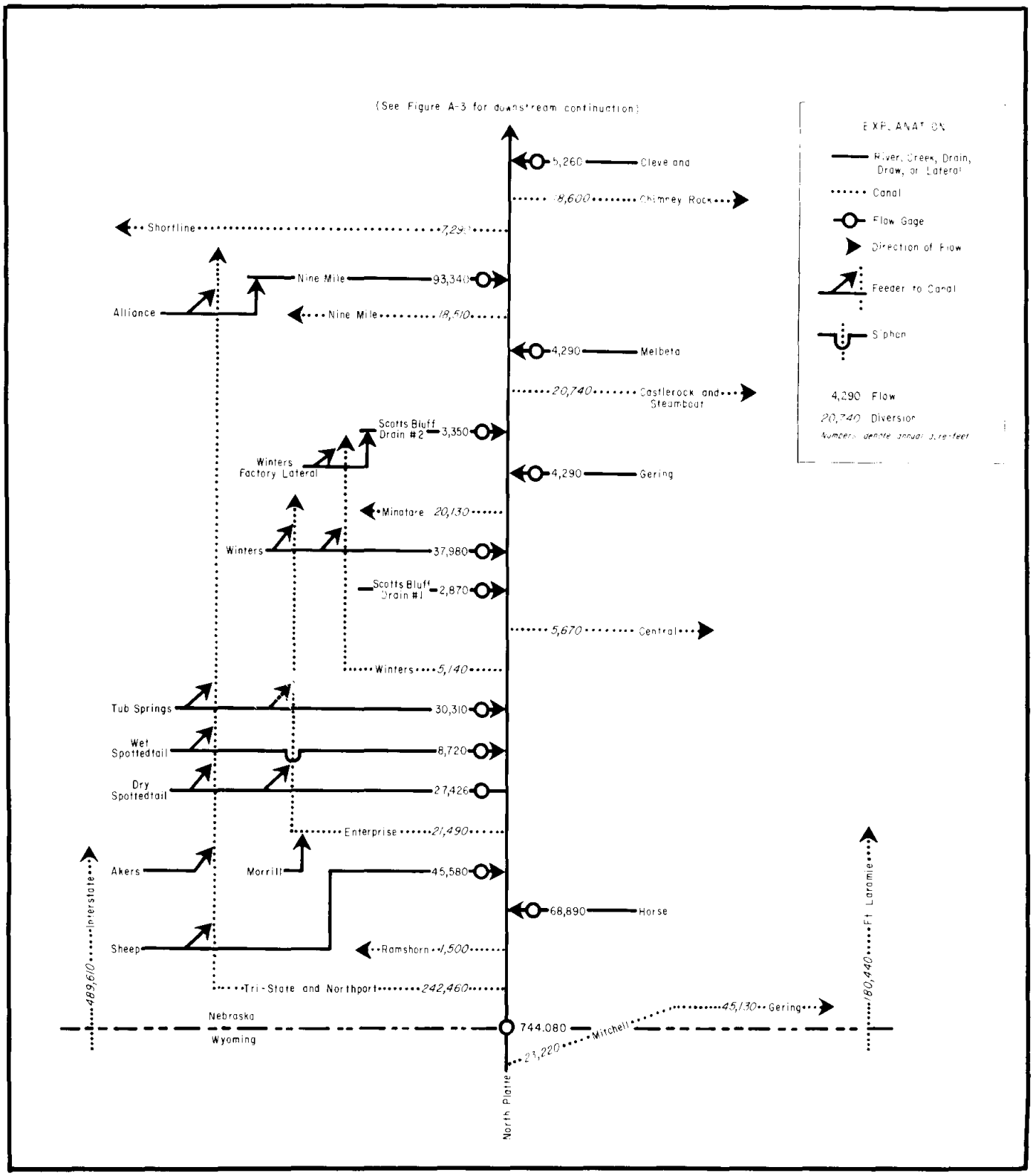


FIGURE A-2

DIAGRAM OF THE NORTH PLATTE RIVER AND DRAINAGE BASIN FROM THE STATE LINE TO HIGHWAY U.S. 26

Note: North is generally to the left in this diagram.

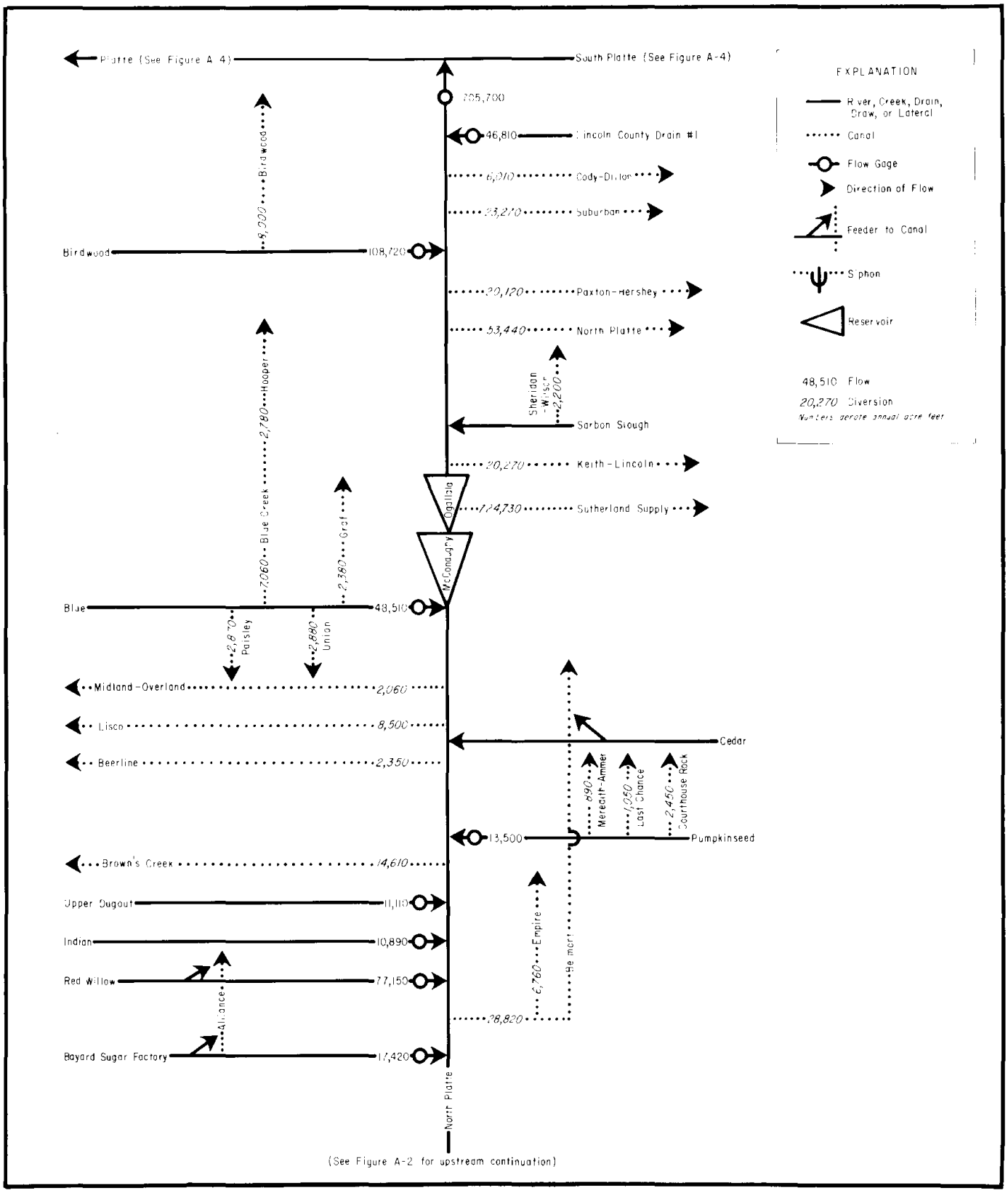


FIGURE A-3

DIAGRAM OF THE NORTH PALTTE RIVER AND DRAINAGE BASIN FROM HIGHWAY U.S. 26 TO THE PLATTE RIVER

Note: North is generally to the left in this diagram.

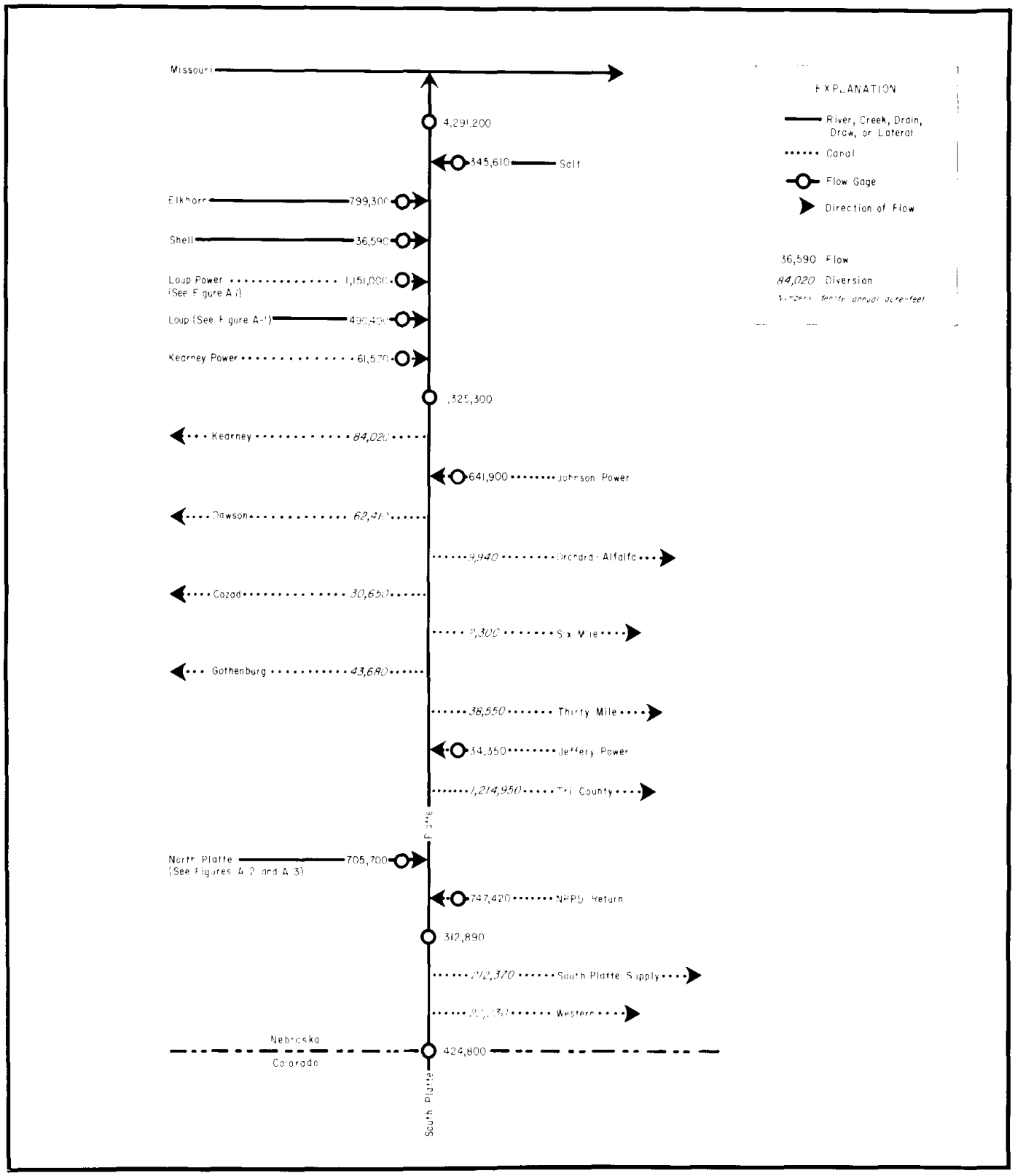
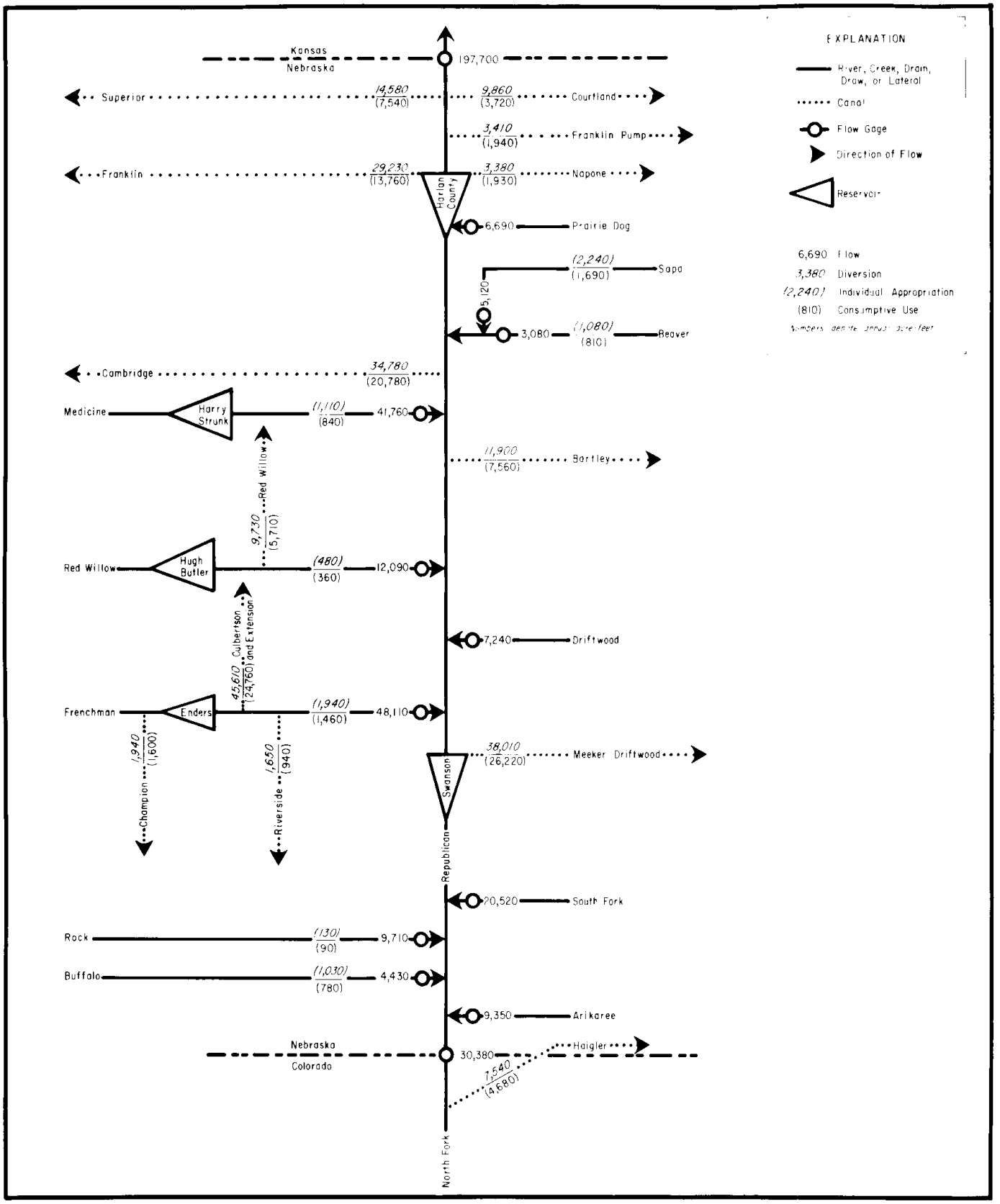


FIGURE A-4

DIAGRAM OF THE SOUTH PLATTE RIVER AND DRAINAGE BASIN FROM THE STATE LINE TO THE PLATTE RIVER AND OF THE PLATTE RIVER FROM THE CONFLUENCE TO THE MISSOURI RIVER

Note: North is generally to the left in this diagram.



FIGURES A-5
DIAGRAM OF THE REPUBLICAN RIVER AND DRAINAGE BASIN FROM STATE LINE TO STATE LINE

Note: North is generally to the left in this diagram.

TABLE A-7

SURFACE-WATER SUPPLIES
REPUBLICAN RIVER BASIN

AVERAGE ANNUAL QUANTITIES IN ACRE FEET (1969-78)

SUB-BASIN	SUPPLY	CONSUMPTION	WATER YIELD	RANGE OF WATER YIELD
Prairie Dog Creek	6,880	190	6,690	3,510 — 13,970
Sappa Creek	9,320	1,700	7,620	1,660 — 18,960
Beaver Creek	3,190	810	2,380	360 — 6,090
Medicine Creek	41,720	3,480	38,550	33,550 — 54,430
Red Willow Creek	18,840	9,100	9,740	5,650 — 15,620
Driftwood Creek	7,210	0	7,210	4,890 — 10,370
Frenchman River	77,880	30,810	47,070	34,710 — 58,870
So. Fk. Republican River	20,520	0	20,520	7,950 — 31,910
Rock Creek	9,810	90	9,720	8,870 — 10,360
Buffalo Creek	5,210	780	4,430	3,740 — 5,030
Arikaree River	9,390	0	9,390	2,670 — 16,320
No. Fk. and Main Stem Republic River**	120,650	106,910	13,740	(-) 84,430 — (+) 118,780

* INCLUDES EVAPORATION FROM MAJOR RESERVOIRS
** INCLUDES BLACKWOOD CREEK

Source: Department of Water Resources July 1980

Data used in preparation of Table A-7 was compiled from the annual reports prepared by the Engineering Committee of the Republican River Compact Administration. That committee routinely has relied upon gaging-station records, diversion records (published and unpublished) and evaporation and return-flow estimates provided by various state and federal agencies. The quantities listed are the average annual renewable supply of each sub-basin. The amounts were computed from data collected during the ten-year period 1969-1978.

Maximum variation of the water yield ranged from 14 percent to 256 percent of the ten-year average. The range within most sub-basins was considerably less. Negative quantities (found in the range of water yields for the North Fork and Main Stem) indicate periods in which in-sub-basin supply was insufficient to satisfy demand. Hence, tributary and out-of-state inflows fulfilled the needs of North Fork and Main Stem users.

Water impounded in Bonny Reservoir located in east-central Colorado is a potential source of supplemental water. Some 41,340 acre-feet annually was originally intended for irrigation of the unorganized and unconstructed Arnel Unit (the project was ultimately declared economically infeasible in 1977). With the exception of 1977, when Nebraska's Frenchman-Cambridge Irrigation District purchased nearly 4,000 acre-feet, average annual storage releases were nearly 800 acre-feet. Thus, perhaps as much as 40,500 acre-feet could be imported to Nebraska. Since Colorado's Division of Wildlife has essentially proposed an outright purchase of the reservoir, however, this source of supplemental supply is somewhat in doubt.

IX. WATER SUPPLIES IN THE LITTLE BLUE RIVER BASIN

The entire Little Blue River Basin generally possesses a large surplus of surface water over and above the quantity consumed, when the water balance is evaluated on an average annual basis. During the irrigation season, however, spot shortages have occurred in the upper two-thirds of the basin. The maximum variation of the water yield ranged from 40 to 200 percent of the ten-year average for the two basins involved. Table A-8 provides a summary of the surface water supply, consumption and the remaining water yield for the two segments of the basin.

TABLE A-8

SURFACE-WATER SUPPLIES
LITTLE BLUE RIVER BASIN

AVERAGE ANNUAL QUANTITIES IN ACRE FEET (1969-78)

SUB-BASIN	SUPPLY	CONSUMPTION	WATER YIELD	RANGE OF WATER YIELD
Little Blue, Deweese Upstream**	119,130	2,330	116,800	46,460 — 237,800
Little Blue, Hollenberg to Deweese**	290,500	5,660	284,840	105,000 — 512,000

* EXCLUDES EVAPORATION
** INCLUDES: ALL MINOR TRIBUTARIES

Source: Department of Water Resources October 1980

Little Blue River, Deweese Upstream. The headwaters of the Little Blue River originate in the region of south-central Nebraska known as the Rainwater Basin. This region of shallow depressions and silty clay coils is characterized by shallow ponds which form during the spring rains and largely evaporate by the beginning of the irrigation season. As indicated by the figures listed in Table A-8, the surface-water consumption in a given year is only a small fraction of the available supply. Nevertheless, during some years, the entire river above Deweese has not had sufficient flow to meet the needs of those wishing to irrigate.

Little Blue, Hollenberg to Deweese. This sub-basin has upland topography and soils which are similar to that of the region upstream of Deweese. The feature which distinguishes the lower sub-basin from its headwaters is the nature of the river valley in the portion of the watershed downstream from Alexandria. The river below Alexandria meanders through a layer of sand and gravel which contributes greatly to the base flow and general water supply of the lower basin. In drought years, the spring-fed lower portion of Big Sandy Creek has contributed a significant portion of the total flow measured at the Hollenberg, Kansas gage. As a result of the gaining reach, the portions of the sub-basin which have not had sufficient water supplies to meet irrigation needs during drought years are located upstream of the town of Oak, and along portions of some tributary streams.

X. WATER SUPPLIES IN THE BIG BLUE RIVER BASIN

Most of the Big Blue Basin has experienced periods in which the supply of surface water has not been sufficient to satisfy irrigation demands, despite the figures provided in Table A-9, which indicate the existence of a large surplus on an average annual basis. Only the portion of the basin downstream from Crete has been relatively free of serious water shortages during the summer months. The maximum variation of the water yield ranged from 22 to 233 percent of the ten-year average for the sub-basins. Table A-9 provides a summary of the surface water supply consumption and the remaining water yield for the sub-basins of the Big Blue Watershed.

Lincoln Creek. Lincoln Creek rises in the gently rolling prairie of east-central Nebraska. Although the lower portion of Lincoln Creek maintains some flow even during the worst drought periods, the supply during dry years is insufficient to meet the demand within the sub-basin and dependent regions of the Big Blue downstream from the mouth.

West Fork of the Big Blue. The West Fork Basin lies directly south of the Lincoln Creek Watershed, and originates in the same physiographic region. Although

TABLE A-9

SURFACE-WATER SUPPLIES BIG BLUE RIVER BASIN

AVERAGE ANNUAL QUANTITIES IN ACRE FEET (1969-78)

SUB-BASIN	SUPPLY	CONSUMPTION	WATER YIELD	RANGE OF WATER YIELD
Lincoln Creek	30,060	2,030	28,030	9,280 — 57,000
West Fork of Big Blue above Dorchester	120,760	9,170	111,590	56,790 — 228,000
Big Blue, Crete Upstream	74,160	2,500	71,660	21,360 — 167,270
Turkey Creek	61,030	3,080	57,950	13,330 — 131,400
Big Blue, Barneston to Crete	330,180	4,880	325,300	71,890 — 660,640

* EXCLUDES EVAPORATION

Source: Department of Water Resources October 1980

the West Fork drainage area is only approximately three times as large as the Lincoln Creek Watershed, it supports an average annual flow almost four times greater. Unlike Lincoln Creek, few surface-water shortages have been reported on the West Fork in recent years. Much of the reason for the favorite surface water supply situation on the West Fork during the summer, can be attributed to the large-scale use of groundwater sources of irrigation water, within the watershed.

Big Blue River, Crete Upstream. Due to the relatively minor contribution of groundwater seepage to the flow in this portion of the river, the water supply at any given time is heavily dependent upon short-term climatic fluctuations. The Upper Big Blue River Basin is subject to severe water-supply shortages during dry and moderately dry summers. In addition, zero flow conditions have been noted for weeks at a time during the winter at Surprise, when drought and extremely cold temperatures have prevented surface water from entering the channel. During periods of abundant rainfall, on the other hand, flooding conditions have been known to persist for several days at a time, due to the slow channel velocities produced by the river as it meanders through the nearly level plains which form its headwaters.

Turkey Creek. This 460-square-mile basin is representative of the majority of tributary watersheds in the Big Blue Basin. It rises in the flat eastern Nebraska Plains region, and meanders through a wide shallow valley. Although the stream rarely goes dry, there have been several instances when the flow has been insufficient to meet the needs of water users.

Big Blue River, Barneston to Crete. This portion of the Big Blue Basin has been relatively free of water shortages, and has been subject to flooding on numerous occasions. Much of the credit for the favorable water supply-demand balance in this subbasin may be attributed to the wide use of well water for irrigation. Although irrigation season water shortages don't currently plague this portion of the Big Blue River Basin as they do in regions upstream, discharges near the Kansas border have occasionally fallen below those levels guaranteed to Kansas by the Big Blue Compact, during dry summers.

XI. WATER SUPPLIES IN THE WEEPING WATER AND NEMAHA BASINS

The Missouri River tributary rivers and streams of southeast Nebraska drain a topographic region consisting of loess hills, glacial debris, and bedrock outcrops. Because of the geologic history of the basins, soil and hydrologic conditions may vary widely within a distance of a few hundred yards. The maximum variation of the water yield ranged from 22 to 236 percent of the ten-year average for the three basins involved. Table A-10 provides a summary of the surface-water supply, consumption and the remaining water yield for the major streams of the region.

Weeping Water Creek. Although the data in Table A-10 indicates that less than three percent of the available water supply in this basin is consumed in an average year, irrigation is often impossible during very dry years due to the lack of suitable flow. As the majority of the annual discharge is produced by surface runoff, it is not uncommon for over one-half of the annual flow to occur within a single month. In its present condition, Weeping Water Creek is not a reliable source of surface water supply.

Little Nemaha River. The Little Nemaha River has been a dependable source of surface water for irrigation during drought years until the late seventies. The summer of 1977 marked the first time that the river could not satisfy the irrigation demand. Much of the reason for the shortfall can be attributed to the large increase in the number of irrigators during the mid-seventies. Unlike most areas of the state, irrigators have not been able to rely upon groundwater for their needs, due to the lack of a suitable aquifer. As a result, continued development of water resources within the Little Nemaha River Basin will depend largely upon the surface water provided by the river.

Big Nemaha River. The Big Nemaha River Basin also experienced its first surface water shortfall during 1977, as a result of conditions similar to the ones which occurred in the Little Nemaha Basin. The greatest shortfall occurred along the reach between Table Rock and Salem and other shortages were reported on the North Fork. Although annual water supplies far exceed consumption, even during dry years, shortages during the critical months of July and August may re-occur.

TABLE A-10

SURFACE-WATER SUPPLIES WEEPING WATER AND NEMAHA BASINS

AVERAGE ANNUAL QUANTITIES IN ACRE FEET (1969-78)

SUB-BASIN	SUPPLY	CONSUMPTION	WATER YIELD	RANGE OF WATER YIELD
Weeping Water Creek	65,440	1,620	63,820	20,250 — 136,300
Little Nemaha River	200,970	2,170	198,800	61,700 — 456,900
Big Nemaha River	420,190	3,030	417,160	89,850 — 983,800

* EXCLUDES EVAPORATION

Source: Department of Water Resources October 1980

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APPENDIX B

by
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APPENDIX B
PROPOSED SITES AND EXISTING FACILITIES FOR STORAGE OF 1,000 ACRE-FEET OR MORE IN NEBRASKA

TABLE OF PROPOSED SITES AND EXISTING FACILITIES FOR STORAGE OF 1,000 ACRE-FEET OR MORE IN NEBRASKA

This table give further information on sites and facilities shown in Figure 3-6, *Supplemental Water Supplies Policy Issue Study.*

Compiled by the Conservation and Survey Division, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln in 1982 from information as supplied by Ainsworth Irrigation District; Clyde E. Burdick; Central Nebraska Public Power and Irrigation District; Alfred Drayton; Loup Basin Reclamation District; Loup Power District; Upper and Lower Big Blue; Lower Elkhorn, Little Blue, Papio, Middle and Lower Niobrara, North, Twin, and Central Platte, Lower Platte North and South, Middle Republican, and Tri-Basin Natural Resources Districts; Nebraska Department of Water Resources, Natural Resources Commission, and Public Power District; Tri-State Generation and Transmission Association, Inc.; and U.S. Bureau of Reclamation, Department of Army-Corps of Engineers, Geological Survey, and Soil Conservation Service.

NOTES:

1. Constructed or under construction
2. Require water from outside local drainage
3. Facility site proposed by more than one agency
4. Authorized
5. Rejected site
6. Normal storage given in 1,000 acre-feet. Normal storage includes active, inactive, and dead for BR; conservation and sediment for CE; and permanent pool or principal spillway for SCS.
7. Abbreviations:

BR	U.S. Bureau of Reclamation
CE	U.S. Department of Army, Corps of Engineers
CE-EDA	Studied by CE for High Plains-Ogallala Aquifer Study (EDA)
CE-MRBC	Studied by CE for Missouri River Basin Commission Studies
CNPPID	Central Nebraska Public Power and Irrigation District
CPPD	Custer Public Power District
GPC	Nebraska Game and Parks Commission
IRRIG	Local irrigation districts
LBRD	Loup Basin Reclamation District
LPD	Loup Power District
NPPD	Nebraska Public Power District
NRD	Local natural resource district
PRIV	Private ownership
SCS	U.S. Soil Conservation Service
UNK	Unknown
WID	Whitney Irrigation District

Survey of Proposed Reservoirs

No.	Name	Stream	County	Storage[6]	Agency[7]
	A. WHITE-HAT				
A-1	Whitney[1]	White	Dawes	10.9	WID
	B. NIOBRARA				
B-1	Kilpatrick[1]	Snake Crk	Box Butte	1.7	PRIV
B-2	Box Butte[1]	Niobrara	Dawes	31.1	BR
B-3	Colwell	Niobrara	Sheridan	29.3	BR
B-4	Clinton	Niobrara	Sheridan	250.0	BR
B-5	Antelope Creek[5]	Antelope Crk	Sheridan	UNK[7]	BR
B-6	Bear Creek[5]	Bear Crk	Cherry	UNK	BR
B-7	Boiling Springs	Niobrara	Cherry	132.4	BR
B-8	Original Merritt[5]	Snake	Cherry	UNK	BR
B-9	Boardman Creek[5]	Boardman Crk	Cherry	UNK	BR
B-10	Merritt[1]	Snake	Cherry	74.5	BR
B-11	Kilgore	Niobrara	Cherry	73.8	BR
B-12	Crookston	Niobrara	Cherry	97.8	BR
B-13	Thatcher	Niobrara	Cherry	105.3	BR
B-14	Copeland	Beaver Crk	Cherry	100.0	BR
B-15	Sparks	Niobrara	Cherry	33.8	BR
B-16	Carpenter[5]	Plum Crk	Brown	UNK	BR
B-17	Brush Creek[5]	Plum Crk	Brown	UNK	BR
B-18	Upper Plum Creek	Plum Crk	Brown	15.3	BR
B-19	Afterbay[5]	Plum Crk Trib	Brown	UNK	BR
B-20	Plum Creek	Plum Crk	Brown	130.7	BR
B-21	Lower Plum Creek	Plum Crk	Brown	316.6	BR
B-22	Norden[4]	Niobrara	Keya Paha	415.8	BR
B-23	Meadville	Niobrara	Keya Paha	488.6	BR
B-24	Bone Creek	Long Pine	Brown	97.6	BR
B-25	Winfield[5]	Long Pine	Brown	UNK	BR
B-26	Long Pine	Long Pine	Rock	115.3	BR
B-27	Elk	Niobrara	Keya Paha	1,806.0	BR
B-28	Holt Creek	Holt Crk	Keya Paha	3.0	SCS
B-29	Kaupp[1]	Indian	Keya Paha	1.6	PRIV
B-30	Spring Creek	Spring Crk	Keya Paha	3.0	SCS
B-31	Coon Creek	Coon Crk	Keya Paha	2.0	SCS
B-32	Niobrara	Niobrara	Boyd	1,788.0	BR
B-33	Middle Branch[5]	Eagle Crk	Holt	2.0	BR
B-34	Eagle Creek[2]	Eagle Crk	Holt	133.0	CE-EDA
B-35	Spencer[1]	Niobrara	Holt	2.3	NPPD
B-36	Verdel	Niobrara	Knox	320.0	BR
	C. MISSOURI TRIBUTARIES				
C-1	McCully	Ponca Crk	Boyd	5.4	BR
C-2	Ponca Creek	Ponca Crk	Boyd	52.5	BR
C-3	Boyd County Storage[2]	Missouri Trib	Boyd	60.0	NPPD
C-4	Boyd County Storage[2]	Ponca Crk Trib	Boyd	74.0	NPPD
C-5	West Bow[2]	West Bow Crk	Cedar	74.3	BR
C-6	Pearl[2]	Pearl Crk	Cedar	78.5	BR
C-7	Summit Lake[1]	Tekamah Crk	Burt	1.4	SCS

Survey of Proposed Reservoirs Con't

No.	Name	Stream	County	Storage[6]	Agency[7]
C-8	West Kennard[4]	Big Papio Trib	Washington	5.5	CE
C-9	East Kennard[4]	Big Papio	Washington	6.0	CE
C-10	County Line[4]	Big Papio	Washington	5.5	CE
C-11	Washington	Big Papio Trib	Washington	2.8	CE
C-12	3-A	Big Papio	Douglas	18.9	CE
C-13	Thomas Creek[4]	Thomas Crk	Douglas	1.2	CE
C-14	Irvington[1]	Knight Crk	Douglas	3.9	CE
C-15	Military[1]	Big Papio Trib	Douglas	1.5	CE
C-16	Longeran[1]	Knight Crk Trib	Douglas	2.0	PRIV
C-17	West Dodge[4]	Big Papio Trib	Douglas	4.2	CE
C-18	Millard[4]	Box Elder Crk	Douglas	4.9	CE
C-19	Gretna[4]	Big Papio Trib	Sarpy	1.1	CE
C-20	Chalco[1]	Big Papio Trib	Sarpy	3.6	CE
		D. LOUP			
D-1	North Loup Storage	North Loup	Cherry	113.0	BR
D-2	Mullen	Middle Loup	Hooker	55.0	BR
D-3	Seneca[5]	Middle Loup	Thomas	UNK	CPPD
D-4	Dismal	Dismal	Thomas	230.0	BR
D-5	Dunning	Middle Loup	Blaine	100.0	NPPD
D-6	Milburn	Middle Loup	Blaine	26.6	CE-MRBC
D-7	Almeria	North Loup	Loup	536.0	BR
D-8	Calamus[3]	Calamus	Garfield	127.3	BR[1]
				24.1	CE-MRBC
D-9	North Loup	North Loup	Garfield	276.0	BR
D-10	Round Valley[2]	Middle Loup Trib	Custer	100.0	UNK
D-11	Woods Park[2]	Middle Loup Trib	Custer	25.0	NPPD
D-12	Spalding[2]&[3]	Cedar	Greeley	81.4	BR
				67.0	CE-EDA
D-13	Loretto	Beaver Crk	Boone	125.0	BR
D-14	Davis Creek[3]	Davis Crk	Valley	32.5	BR[4]
				2.2	CE-MRBC
D-15	Large Davis Creek	Davis Crk	Howard	423.0	BR
D-16	Sherman County[1]	Oak Crk	Sherman	69.1	BR
D-17	Jonak-Zocholl[2]	Middle Loup Trib	Howard	7.1	LBRD
D-18	Munson	Munson Crk	Howard	60.0	BR
D-19	Lukasiewicz[2]	Middle Loup Trib	Howard	4.0	LBRD
D-20	Gdanitz[2]	Middle Loup Trib	Howard	3.5	LBRD
D-21	Cushing	Loup Trib	Howard	155.0	BR
D-22	South Loup	South Loup	Buffalo	491.7	BR
D-23	Pleasanton	South Loup	Buffalo	560.0	BR
D-24	Poole	South Loup	Buffalo	200.0	BR
D-25	Rockville[2]&[3]	Middle Loup	Sherman	678.0	BR
				425.0	CE-EDA
D-26	Dannebrog[2]	Middle Loup Trib	Howard	2.0	LBRD
D-27	St. Paul[2]	Middle Loup Trib	Howard	2.0	LBRD
D-28	Fullerton[3]	Loup	Nance	455.0	BR
				800	CE-EDA
D-29	Beaver Creek	Beaver Crk Trib	Boone	2.0	SCS
D-30	Beaver Creek	O'Neill Valley	Boone	1.2	SCS
D-31	Beaver Creek	Votheese Creek	Boone	1.8	SCS
D-32	Beaver Creek	Beaver Crk	Boone	248.0	BR
D-33	Beaver Creek	Bogas Crk	Boone	1.2	SCS
D-34	Beaver Creek	Beaver Crk Trib	Platte	1.3	SCS
D-35	Beaver Creek	Skedee Crk	Nance	1.3	SCS

Survey of Proposed Reservoirs Con't

No.	Name	Stream	County	Storage[6]	Agency[7]
		E. ELKHORN			
E-1	Rosedale[2]	Clearwater Crk	Antelope	122.0	BR
E-2	St. Clair[2]	Cedar Crk	Antelope	310.0	BR
E-3	Battle Creek	Battle Crk	Madison	13.6	CE-MRBC
E-4	Millard	N. Fork Elkhorn	Pierce	9.6	CE-MRBC
E-5	Osmond	N. Fork Elkhorn	Pierce	16.0	CE-MRBC
E-6	Willow Creek[1]	Willow Crk	Pierce	6.6	NRD
E-7	Dry Creek	Dry Crk	Pierce	5.9	CE-MRBC
E-8	Yankton Slough[2]	N. Fork Elkhorn	Pierce	1.0	SCS
E-9	Deer Creek	Deer Crk	Wayne	1.4	SCS
E-10	So. Logan Creek[2]	S. Logan Crk Trib	Wayne	1.3	SCS
E-11	Upper Logan Creek	Baker Crk	Cedar	1.3	SCS
E-12	Dog Creek	Dog Crk	Wayne	1.6	SCS
E-13	So. Logan Creek[2]	S. Logan Crk Trib	Dixon	1.1	SCS
E-14	So. Logan Creek	South Logan Crk	Wayne	2.3	SCS
E-15	Plum Creek	Plum Crk	Wayne	1.4	SCS
E-16	Plum Creek	Plum Crk	Wayne	1.2	SCS
E-17	Pender	Logan Crk	Thurston	246.1	BR
E-18	Humbug Creek	Humbug Crk	Stanton	10.2	CE-MRBC
E-19	Maskenthine[1]	Maskenthine Crk	Stanton	1.0	NRD
E-20	Salem	Elkhorn Trib	Cuming	5.3	CE-MRBC
E-21	Plum Creek	Plum Crk Trib	Cuming	1.0	SCS
E-22	Treaty	Plum Crk	Cuming	31.1	CE-MRBC
E-23	Madison[2]	Union Crk	Madison	22.3	CE-MRBC
E-24	Meridian Creek[2]	Meridian Crk	Stanton	16.7	CE-MRBC
E-25	Site 33	W. Fork Maple Crk	Colfax	1.2	SCS
E-26	Site 51	W. Fork Maple Crk	Colfax	3.7	SCS
E-27	Site 7	E. Fork Maple Crk	Colfax	1.2	SCS
E-28	Dodge	Pebble Crk Trib	Dodge	3.1	CE-MRBC
E-29	Snyder	Pebble Crk Trib	Dodge	2.7	CE-MRBC
E-30	Monterey[3]	Pebble Crk	Cuming	211.1	BR & CE
E-31	Garfield	Cuming Crk	Cuming	9.5	CE-MRBC
E-32	Craig	Bell Crk	Burt	12.4	CE-MRBC
E-33	Cuming Creek	Cuming Crk	Cuming	134.0	BR
E-34	Scribner	Elkhorn	Dodge	800.0	CE
E-35	Maple Creek	Maple Crk	Colfax	80.7	CE-MBRC
E-36	Trouble Creek[4]	Trouble Crk	Dodge	1.5	NRD
		F. NORTH PLATTE			
F-1	Braziel	Dry Crk Drn	Scotts Bluff	8.6	BR
F-2	Sheep Creek	Sheep Crk	Scotts Bluff	38.9	BR
F-3	Lake Alice[1]&[2]	Canal	Scotts Bluff	11.0	BR
F-4	Minatare[1]&[2]	Canal	Scotts Bluff	62.2	BR
F-5	Site C	Winters Crk	Scotts Bluff	1.1	SCS
F-6	Sheep Mountain[2]	No. Platte Trib	Banner	150.1	CE-MRBC
F-7	Northport[2]	No. Platte	Morrill	1.2	BR
F-8	Rocky Hollow[2]	Rocky Hollow Crk	Morrill	3,470.0	CE-EDA
F-9	Pumpkin Creek[2]	Pumpkin Crk	Morrill	150.0	CE-MRBC
F-10	Crescent[1]	Blue Crk Trib	Garden	4.3	PRIV
F-11	McConaughy Alt.[5]	No. Platte	Garden	UNK	UNK
F-12	McConaughy[1]	No. Platte	Keith	1,948.0	CNPPID
F-13	Ogallala	No. Platte	Keith	1.0	NPPD

Survey of Proposed Reservoirs Con't

No.	Name	Stream	County	Storage[6]	Agency[7]
		G. SOUTH PLATTE			
G-1	Oliver[1]	Lodgepole Crk	Kimball	7.4	NRD
G-2	Sidney[2]	Sidney Draw	Cheyenne	310.0	CE-EDA
G-3	Perkins (6 sites)[2]	Canal	Keith	165.0	NRD
G-4	Roscoe Draw[2]	Canal	Keith	236.0	CE-EDA
G-5	Sutherland[1]&[2]	Canal	Lincoln	181.5	NPPD
G-6	Maloney[1]&[2]	Canal	Lincoln	21.0	NPPD
		H. MIDDLE PLATTE			
H-1	Box Elder[2]	Canal	Lincoln	90.0	CE-EDA
H-2	Snell[2]	Canal	Lincoln	130.0	CE-EDA
H-3	Jeffrey[1]&[2]	Canal	Lincoln	11.5	CNPPID
H-4	Roten Valley[2]	Stump Crk	Dawson	510.0	CE-EDA
H-5	Site 19-B[1]	Stump Crk	Dawson	1.0	SCS
H-6	Site 11-A[1]	Spring Crk	Dawson	1.0	SCS
H-7	West Buffalo[2]	W. Buffalo Crk	Dawson	169.0	CE-EDA
H-8	Bison	E&W Buffalo Crk	Dawson	163.0	BR
H-9	Crooked Creek[2]	Crooked Crk	Dawson	46.0	CE-EDA
H-10	West Midway[1]&[2]	Canal	Dawson	1.4	CNPPID
H-11	Central Midway[1]&[2]	Canal	Dawson	5.0	CNPPID
H-12	East Midway[1]&[2]	Canal	Dawson	1.5	CNPPID
H-13	Gallagher[1]&[2]	Canal	Dawson	3.3	CNPPID
H-14	Plum Creek[1]&[2]	Canal	Dawson	54.0	CNPPID
H-15	Johnson[1]&[2]	Canal	Gosper	92.0	CNPPID
H-16	Upper Plum[2]&[3]	Canal	Gosper	124.0	CE-EDA
				193.0	BR
H-17	Elwood[1]	Canal	Gosper	37.8	CNPPID
H-18	Philips[1]&[2]	Canal	Gosper	2.2	CNPPID
H-19	Lower Plum[2]&[3]	Plum Crk	Gosper	206.0	CE-EDA
				316.6	BR
H-20	Bertrand[2]	Canal	Gosper	10.0	CNPPID
H-21	Elm Creek	Elm Crk	Buffalo	30.6	NRD
H-22	Turkey #1	Turkey Crk Trib	Buffalo	6.0	NRD
H-23	Turkey #2	Turkey Crk Trib	Buffalo	13.0	NRD
H-24	Amherst	Wood River	Buffalo	402.6	BR
H-25	Wood River #1	Wood River Trib	Buffalo	79.0	NRD
H-26	Wood River #2	Wood River Trib	Buffalo	34.0	NRD
H-27	Turkey #3	Turkey Crk Trib	Buffalo	9.0	NRD
H-28	Wood River #3	Wood River Trib	Buffalo	6.0	NRD
H-29	Dry Creek	Wood River Trib	Buffalo	12.8	BR
H-30	Center	Wood River Trib	Buffalo	10.0	BR
H-31	Buckeye	Wood River Trib	Buffalo	40.0	BR
H-32	Prairie[2]	Prairie Crk	Buffalo	68.5	BR
H-33	Cairo	Dry Crk	Hall	15.4	BR
		I. LOWER PLATTE			
I-1	Shell Creek[1]	Shell Crk	Boone	1.0	SCS
I-2	Tarnov	Shell Crk Trib	Platte	1.1	SCS
I-3	Babcock[1]&[2]	Canal	Platte	16.0	LPD
I-4	Shell Creek[2]	Shell Crk	Colfax	183.0	BR
I-5	Linwood[2]&[3]	Skull Crk	Butler	42.0	CE or BR
I-6	Sand Creek	Wahoo Crk	Saunders	20.8	CE
I-7	Sand Creek	Wahoo Crk Trib	Saunders	2.2	SCS

Survey of Proposed Reservoirs Con't

No.	Name	Stream	County	Storage[6]	Agency[7]
I-8	Duck Creek	Wahoo Crk	Saunders	8.6	CE
I-9	Wahoo Creek	N. Fork Wahoo Crk	Saunders	1.1	SCS
I-10	Dunlap Creek	Wahoo Crk Trib	Saunders	1.1	SCS
I-11	Wahoo Creek[1]	N. Fork Wahoo Crk	Saunders	1.1	SCS
I-12	Miller Branch[1]	Wahoo Crk Trib	Saunders	1.4	SCS
I-13	Platte	Platte	Cass	3,000.0	CE
I-14	Branched Oak[1]	Oak Crk	Lancaster	27.0	CE
I-15	Twin Lakes[1]	Middle Crk	Seward	2.8	CE
I-16	Pawnee[1]	Middle Crk	Lancaster	8.6	CE
I-17	Conestoga[1]	Homes Crk	Lancaster	2.7	CE
I-18	Yankee Hill[1]	Salt Crk Trib	Lancaster	2.0	CE
I-19	Bluestem[1]	Salt Crk Trib	Lancaster	3.0	CE
I-20	Olive Creek[1]	Olive Crk	Lancaster	1.5	CE
I-21	Stage Coach[1]	Salt Crk Trib	Lancaster	2.0	CE
I-22	Wagon Train[1]	Salt Crk Trib	Lancaster	2.6	CE
	J. REPUBLICAN				
J-1	Kilpatrick[1]	Frenchman	Chase	1.0	PRIV
J-2	Enders[1]	Frenchman	Chase	44.5	BR
J-3	Enders[2]	Canal	Chase	UNK	IRRIG
J-4	Wauneta[2]	Stinking Wtr Crk	Hayes	425.0	CE-EDA
J-5	Blackwood Creek #1[2]	Blackwood Crk	Hayes	270.0	CE-EDA
J-6	Red Willow Creek[2]	Red Willow Crk	Hayes	362.5	CE-EDA
J-7	Swanson[1]	Republican	Hitchcock	120.0	BR
J-8	Hugh Butler[1]	Red Willow Crk	Frontier	37.8	BR
J-9	East Canyon Creek[1]	Medicine Crk Trib	Frontier	1.3	SCS
J-10	Curtis Creek[1]	Medicine Crk Trib	Frontier	1.0	SCS
J-11	Dry Creek[1]	Medicine Crk Trib	Frontier	1.0	SCS
J-12	Cedar Creek[1]	Medicine Crk Trib	Frontier	1.7	SCS
J-13	Harry Strunk[1]	Medicine Crk	Frontier	37.1	BR
J-14	Harlan County[1]	Republican	Harlan	319.8	CE-BR
	K. LITTLE BLUE				
K-1	Campbell[2]&[3]	Little Blue	Franklin	27.5	CE-EDA
				50.1	NRD
K-2	Cottonwood[2]	Cottonwood Crk	Adams	20.0	NRD
K-3	Pauline[2]	Little Blue	Adams	280.0	CE-EDA
K-4	Big Sandy #1[1]	Big Sandy Crk	Clay	13.0	NRD
K-5	Edgar Recharge	Big Sandy	Clay	3.1	NRD
K-6	Angus	Little Blue	Nuckolls	440.0	BR
K-7	Oak	Little Blue	Nuckolls	56.5	BR
K-8	Lower Big Sandy[2]&[3]	Big Sandy Crk	Thayer	37.0	CE-EDA
				6.5	NRD
K-9	Bruning Recharge	Big Sandy Trib	Thayer	2.0	NRD
K-10	Hebron #1	So. Fork Big Sandy	Thayer	6.1	NRD
K-11	Hebron #2	Little Blue	Thayer	56.5	BR
K-12	Deshler	Spring Crk Trib	Thayer	1.1	NRD
	L. BIG BLUE				
L-1	Aurora[2]	Big Blue	Hamilton	26.0	NRD
L-2	Stockman[2]	W. Fork Big Blue	Hamilton	60.0	NRD
L-3	Stockman[2]	W. Fork Big Blue	Hamilton	90.0	CE-EDA
L-4	Lincoln Creek II[2]	Lincoln Crk	Hamilton	65.0	CE-EDA

Survey of Proposed Reservoirs Con't

No.	Name	Stream	County	Storage[6]	Agency[7]
L-5	Hampton[2]	Beaver Crk	Hamilton	28.5	NRD
L-6	Bradshaw[2]	Lincoln Crk	York	19.0	NRD
L-7	Dam Site B[2]	Lincoln Crk	York	76.0	CE-EDA
L-8	York[2]	Beaver Crk	York	69.7	CE-EDA
L-9	Dam Site G[2]	W. Fork Big Blue	York	95.0	CE-EDA
L-10	Fairmont[2]	W. Fork Big Blue	Fillmore	192.0	CE-EDA
L-11	Surprise #1[2]	Big Blue	Polk	125.0	CE-EDA
L-12	Surprise #2[2]&[3]	Big Blue	Butler	176.7	BR
				56.0	NRD
L-13	Dam Site A[2]	Big Blue	Butler	114.0	CE-EDA
L-14	Thayer[2]	Lincoln Crk	York	112.0	CE-EDA
L-15	Dam Site C[2]	Lincoln Crk	Seward	381.0	CE-EDA
L-16	Dam Site X	Beaver Crk	York	148.0	CE-EDA
L-17	Dam Site E	Big Blue	Seward	278.7	CE-EDA
L-18	Seward View	Lincoln Crk	Seward	227.3	BR
L-19	Dam Site F	Plum Crk	Seward	81.3	CE
L-20	Beaver Crossing[2]&[3]	Indian Crk	Seward	310.0	CE-EDA
				534.5	BR
				110.5	NRD
L-21	Dam Site J[2]	W. Fork Big Blue	Seward	625.0	CE-EDA
L-22	Sunbeam	W. Fork Big Blue	Saline	UNK	BR
L-23	Dam Site O[2]	Turkey Crk	Saline	266.0	CE-EDA
L-24	Dam Site N[2]	Turkey Crk	Fillmore	174.0	CE-EDA
L-25	Shestak	Turkey Crk	Saline	180.5	BR
L-26	Dam Site Q[2]	Turkey Crk	Saline	207.0	CE-EDA
L-27	Rockford Lake[1]	Mud Crk	Gage	1.8	SCS
		M. NEMAHA			
M-1	Bennet[3]	Upper L. Nemaha	Lancaster	29.8	CE
				4.6	BR
M-2	Galloway[3]	Silver Crk	Otoe	9.5	CE
				7.4	BR
M-3	Palmyra[3]	Hooper Crk	Otoe	28.2	CE
				20.6	BR
M-4	Owl Creek[3]	Owl Crk	Otoe	7.8	CE
				5.7	BR
M-5	Cass	N. Fork L. Nemaha	Cass	22.0	BR
M-6	Otoe	Flood Crk	Otoe	22.0	BR
M-7	Beaver Lake[1]	Rock Crk	Cass	8.5	PRIV
M-8	Douglas[3]	Muddy Crk	Otoe	7.2	CE
				5.4	BR
M-9	Sanders[3]	Sanders Crk	Otoe	5.8	CE
				3.9	BR
M-10	Sterling	North Fork	Johnson	16.3	CE
M-11	Spring[3]	Spring Crk	Johnson	7.1	CE
				6.4	BR
M-12	Tecumseh	Yankee Crk	Johnson	27.3	CE
M-13	Auburn	Muddy Crk	Nemaha	29.9	CE
M-14	Stella	L. Muddy Crk	Richardson	23.1	CE
M-15	Humboldt	Long Branch Crk	Richardson	28.7	CE
M-16	Burchard Lake[1]	Turkey Crk Trib	Pawnee	1.8	GPC
M-17	DuBois	Turkey Crk	Pawnee	84.8	CE

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APPENDIX C

by

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APPENDIX C

ENVIRONMENTAL CONSTRAINTS OF SUPPLEMENTAL WATER SUPPLY

An Identification of Constraints and a Survey Evaluation Using the Delphi Method

INTRODUCTION

Environmental constraints were developed at a general level and in an experimental fashion. A set of general constraints was derived from a literature review of environmental effects of water development projects and specific Nebraska examples as available. These constraints were related to the basic elements of supplemental water supply projects and presented in an outline form (see below).

The second phase of analysis was an exploratory assessment of expert opinion of the significance of these possible constraints from experts in Federal, State and local agencies and districts (see notes, 3). It was felt that these individuals had first hand knowledge of many specific conditions in Nebraska and would be in a position to provide depth to the general outline of constraints which had been developed. For this purpose, the Delphi technique was used.

This technique (see notes, 1) involves several rounds of survey of a panel of experts in order to determine consensus on some future conditions. The technique was developed for military applications, and used most heavily in "technology assessment" particularly the prediction of when certain products would be marketable. Delphi has since been used more broadly in a general exploratory fashion similar to this usage—to find out in a systematic way, outside of the dynamics of group meetings, what a group of experts thinks about a set of problems or conditions. Results are "fed back" to the respondents in order that they may see where their answers stand in relation to others. Respondants then have a chance to change or maintain their answers on the next round.

In this study, three rounds of a Delphi survey were conducted. The results are described below.

GENERAL ENVIRONMENTAL CONSTRAINTS

The following factors and possible effects constitute the general set of constraints from which the Delphi Survey was developed. They are grouped according to the three general elements of supplemental water supply projects: (1) the area of source of supply; (2) the route of conveyance; and (3) the area of storage and use. References follow at the end of this report (notes, 2). It should be noted that these general constraints do not reflect: regional variation, the specific aspects of the design and management of a project (including mitigation of impacts), in some cases the direction of change (increase or decrease) and trade-offs between environmental constraints and other benefits. Constraints will not necessarily apply to all projects. The degree of constraint is also not described below. These constraints can occur in various combinations and reflect differing possible circumstances.

I. CONSTRAINTS IN AREA OF SOURCE OF SUPPLY

A. SURFACE WATER AS SOURCE OF SUPPLY

1. Impacts of impoundments

a. water quantity:
- increased evaporation
- change in water levels in impoundment based on management
- hydrologic impact on aquifers due to storage, possible recharge through seepage

b. water quality:
- possible increases in TDS, sedimentation, eutrophication
- change in water temperature; possible stratification in impoundments
- possible reduction in turbidity in impoundments
- mixing of water temperatures above dams

c. soils: possible increase in erosion along shorelines or impoundments

d. vegetation/habitat/fish and wildlife populations:

(1) aquatic:
- change from shallow, flowing habitat to deep, still habitat
- change in type of fish populations - species composition - biomass changes
- change in movement of fish populations
- change in silt and mud bottom community
- change in emergent and submergent vegetation and related invertebrates and fish
- change in value of shallow areas of impoundment due to fluctuations; possible sterile littoral zone and reduced value for waterfowl and other wildlife

(2) terrestrial:
- inundation of riparian habitat with subsequent loss of related functions as wintering area for deer, furbearer habitat and area of high density of wildlife
- loss of some populations, dislocation of others
- change in migration of wildlife
- shift from terrestrial ecosystem to aquatic

e. land use:
- increased public access, recreational use of impoundment and shoreline; related requirements for infrastructure, waste disposal, etc.
- secondary impacts of increased land development along shoreline or in area

f. aesthetic/visual:
- change from flowing stream and riparian environment to open water and probably open shoreline
- possible loss of woodland environment depending on site

2. Impacts of diversions and downstream effects of impoundments

a. water supply:
- change in downstream flows; generally reductions, but with possible changes or increases depending on management and releases (peak flows may be reduced and minimum flows increased)

b. water quality:
- change in relation to flow; generally declines with reduced flows
- sediment may be trapped upstream, but loading will vary with flow and management of impoundment

c. vegetation/habitat/fish and wildlife populations:
- change in area of floodplain
- change in riparian and aquatic vegetation, habitat and related fish and wildlife populations; degree will depend on change and variation of streamflow
- change in water temperature may affect fish populations
- possible change in fish movement and spawning

d. land use:
- possible change in recreation or other use due to reduced flow

e. aesthetic/visual:
- change related to impact of reduced flow

B. GROUNDWATER AS SOURCE OF SUPPLY

1. Impacts of withdrawals of groundwater

a. water supply:

(1) groundwater
- reduction in water levels; reduction in wetland areas

(2) surface water
- reduction in streamflow in some areas
- reduction in some lakes and impoundments

b. water quality

c. vegetation/habitat/wildlife populations:
- changes as related to changes in streamflows of wetlands

d. land use: - changes as related to the above effects

II. CONSTRAINTS RELATED TO TRANSFER OF WATER

A. CANALS

1. **Water supply**

a. groundwater - change if seepage from unlined canals

b. surface water - change in flow, if existing canal

2. **Water quality**: change if mixing of water occurs (new and previous flow)

3. **Fish and wildlife**: loss of fish populations at intakes to canals in some locations; barrier and hazard to wildlife

4. **Land use**: interference with access and farming and other activities; safety hazard

B. PIPELINES

1. **Habitat, land use**: some disruption of activities during construction and along corridor; possible loss of habitat and disruption of migration or movement of wildlife populations. Probably change in species compositon of vegetation is associated with pipelines.

C. EXISTING STREAMS

1. **Water supply**: increase in flow with possible variations

2. **Water quality**: change in temperature and possible change in chemical and biological parameters as mixing of water occurs; possible change in sedimentation

3. **Soil**: possible increase in erosion due to increased bank erosion

4. **Vegetation/habitat/fish and wildlife**: possible change as related to streamflow and water quality factors

D. INDUCED RECHARGE

1. **Water Supply**: increase in groundwater level; possible reduction in streamflow

III. CONSTRAINTS IN AREA OF STORAGE AND USE

A. SURFACE WATER STORAGE

1. **Impacts** of on-channel impoundments as noted above on pp 2-3, I.A.1. a-f (change in water supply, water quality and vegetation and wildlife habitat from riparian to aquatic; change in land use and recreation; change in visual aesthetic factors)

2. **Additional changes** resulting from mixing of new and existing water supplies: water quality effects including temperature, concentrations of chemicals, biological parameters, sediment and other factors

3. **Impacts** of off-channel impoundments

a. change in habitat from terrestrial to aquatic

b. wide variation in water level due to management: effect on shoreline zone and general area

B. GROUNDWATER STORAGE

1. **By spreading of new water**

a. water supply: - change in aquifer storage subject to infiltration and percolation rates and characteristics; possible waterlogging of lands; increase in evaporation; geologic constraints in general

b. water quality: - change in temperature; physical and chemical quality of water; sedimentation possible if surface water source; microbial growth possible if surface water source

c. soil/land use: - waterlogging; possible treatment of sediment, microbial growth to maintain infiltration

2. **By injection wells**

a. water supply: - change in aquifer storage

b. water quality: - compatability of new water with existing supply; dilution of existing supply with recharge water; impacts of surface water-sediment,

microbial growth

C. IMPACTS OF USE

1. **Continued, expanded or new development of irrigated agriculture**

2. **Potential for other uses**

3. **Water supply**: effect of use on surface or groundwater supply in terms of rate and amount of seasonal or on-going use; impact on areas of high water table; wetlands; impact on streamflow from surface or

4. **Water quality**: possible increase in nitrate concentrations due to increased irrigated agriculture; possible dilution of nitrate concentrations in existing groundwater supply subject to quality of imported water, or if surface water is used

5. **Soil**: change in erosion could result from increased runoff due to increased use of water, but irrigation could reduce wind erosion; in either case management practices will be a major influence, sandy soils vulnerable to wind erosion in wind and early spring

6. **Vegetation/habitat/wildlife populations**: these factors will be affected by changes in wetland areas, lakes and streamflow, and by the extent of new land which is developed and the reduction in woodlands, mixed grassland and cropland and the intensity of agricultural development

7. **Land use**: as noted, the type of agriculture or other use resulting from the availability of water will be the most significant effect; recreation will be affected by changes in water quantity and quality

8. **Aesthetic and visual resources**: changes will result from new uses of land and their effects on water quantity and quality; landform modifications and agricultural practices will have significant effects as will surface water storage and related streamflow changes

THE DELPHI SURVEY

A Delphi survey of 64 items was developed from the constraints and was conducted in three rounds from early May to mid July 1982. A list of experts was developed which included a representative group of individuals with responsibilities related to supplemental water supply development and its evaluation. The list included representatives of Federal agencies, state agencies, university faculty and staff, Natural Resources District managers, irrigation district representatives and others. In some cases both field staff and central staff were listed. The "panel" of potential respondents numbered 101 people. Of this group 43 responded to the first round of survey; 34 of that group to the second round; and 331 of that group to the third round. The participants were listed at the end (in notes, 3).

Surveys were returned to respondents after each round accompanied by a score sheet indicating the median response and the percent distribution of responses, thus allowing the individual to see where his or her response was in relation to the whole group. Respondents were asked to review this information and either maintain their response or change it and return the survey. In round 2 respondents were asked to make comments about their response if they chose to, particularly if their response was some distance from the median (more than one number). These comments were transcribed and returned to the round 2 respondents as additional information to consider on round 3. Late surveys on rounds 1 and w account for slightly smaller numbers of responses on the data returned to the panel (40 and 30 respectively) than are shown on the final results (43 and 34).

What follows below is a listing of the results for each survey item as presented in the original survey. The results include the median score and percent distribution of responses for each item on rounds 1, 2, and 3 followed by the transcribed comments on each item from round 2 (and rounds 1 and 3 in a few cases). The instructions and the rating scale are included as well.

In reviewing these results, the following factors deserve consideration:

— is the median score particularly high or low?
— is the percent of "0" responses ("uncertain about impact") significantly high –greater than 15-20%?
— are the responses distributed closely on the same side of the scale, e.g. mostly on the positive (1,2,3) or negative (5,6,7) side?; or is there a split, or bimodal response with significant groups on both sides indicating lack of consensus or different views?
— comments which may indicate how the item was perceived.

It should be re-emphasized that what was sought was a best estimate of the significance in positive or negative terms of a previously identified set of constraints or impacts. The items did not deal with specific projects, sites or situations. Hence there was a great deal of possible variation as respondents pointed out in some cases. Additionally, the wording of some questions caused some difficulties. Overall, it should be kept in mid that what was intended was not a full evaluation of a potential project reflecting all of its benefits and costs, but rather an identification and evaluation of those environmental constraints and impacts which could be significant in the development of supplemental water supply projects and policies.

A brief evaluation follows the presentation of the results of rounds 1, 2 and 3 of the Delphi survey.

Delphi Survey Questions on Supplemental Water Supply Environmental Impacts

Background and Instructions

The list of possible impacts which are provided for your evaluation are derived from published literature such as environmental impact statements on Nebraska projects and other more general reports and books. We would like your assistance in determining the applicability and degree and type of impact as related to possible supplemental water supply projects in Nebraska.

On the scale to the right of each item, please rate the potential impact and its significance by circling the appropriate item. Again, remember that we are looking for your best estimate, acknowledging uncertainties, variation and other factors. If you are uncertain, or not familiar with a certain impact, there is a suitable response provided.

Delphi Survey Questions on Supplemental Environmental Impacts

Number of Respondents in Round One	**43**
Number of Respondents in Round Two	**34**
Number of Respondents in Round Three	**31**

Please rate each item according to the following scale:

0	1	2	3	4	5	6	7
uncertain about impact	significant positive impact	moderate positive impact	limited positive impact	no significant impact	limited negative impact	moderate negative impact	significant negative impact

Please rate each **underlined** item by circling the appropriate number on the scale

I. Impacts in Area of Source of Supplemental Water Supply

A. Surface Water as Source of Supply

1. Impacts of Impoundments

001. increased evaporation rates from impoundments

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(5)	0%	0%	9%	11%	18%	48%	9%	2%	100%
#2	(5)	0%	0%	2%	5%	23%	58%	5%	2%	100%
#3	(5)	0%	0%	3%	6%	25%	54%	6%	3%	100%

Comments from Respondents

--("rates" deleted by one respondent, ed.)
--I am not surprised to see this impact underestimated. However in the Missouri River Basin, evaporation from reservoirs accounts for ca. 20% of all water depletions.
--Evaporation also occurs from streams. Whether or not evaporation is increased depends on the individual situation.

002. changes in water levels in impoundments due to management of supply

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(5)	6%	2%	4%	6%	13%	32%	25%	6%	100%
#2	(5)	5%	0%	0%	2%	17%	32%	35%	5%	100%
#3	(5)	0%	0%	0%	3%	19%	32%	38%	6%	100%

Comments from Respondents

--impact with respect to other uses of impoundment (recreation, etc.)
--inhibits aquatic life and recreational use
--negative impact on emergent and submergent vegetation
--mediocre value for recreation because of large fluctuations
--would vary between reservoirs according to uses, degree and season of drawdown

003. hydrologic impact on aquifers due to storage in impoundments; possible seepage

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(3)	9%	11%	32%	20%	11%	9%	2%	2%	100%
#2	(2)	2%	8%	44%	29%	8%	2%	0%	2%	100%
#3	(2)	9%	9%	38%	22%	9%	6%	0%	3%	100%

Comments from Respondents

--(positive) recharge groundwater...(negative) possible high water tables in nearby areas.
--can deteriorate good farmland and need drainage systems
--could have negative impact where groundwater is already abundant
--the recharge to the aquifer from the Tri-County Project supports irrigated agriculture around Cozad and is increasing minimum flows in the Platte
--can have both positive and negative impact depending on the situation

004. possible increase in Total Dissolved Solids (TDS) in impoundment; sedimentation, eutrophication

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(5)	4%	0%	0%	9%	16%	32%	27%	9%	100%
#2	(5)	2%	0%	0%	11%	11%	38%	29%	5%	100%
#3	(5)	0%	0%	0%	12%	12%	41%	25%	6%	100%

Comments from Respondents

--for both 004, 005, I can see the impact of changing from existing conditions as somewhat negative. The impact of the operation of a project might be far less.
--not clearly understood on first reading
--I feel that this is probably good for fish and aquatic life

005. change in water temperature as a result of impoundment of surface water; possible stratification in impoundments

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(4)	9%	0%	4%	11%	32%	25%	11%	4%	100%
#2	(4)	5%	0%	8%	5%	47%	20%	11%	0%	100%
#3	(4)	9%	0%	9%	6%	45%	19%	9%	0%	100%

Comments from Respondents

--for both 004, 005, I can see the impact of changing from existing conditions as somewhat negative. The impact of the operation of a project might be far less.
--considerable problems with fish in Lake McConaughy due to stratification
--the cooler water at the bottom of the reservoir will support more aquatic life than stagnant pools in a drying river bed.
--this should be good for fish
--I feel this will improve fishing and know of no negative impact
--could have negative impact on cold water systems
--(positive) cold and water fishery

006. possible reduction in turbidity in impoundments

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(3)	9%	2%	25%	41%	18%	0%	0%	2%	100%
#2	(3)	8%	0%	29%	41%	20%	0%	0%	0%	100%
#3	(3)	6%	0%	29%	38%	25%	0%	0%	0%	100%

Comment from Respondent

--it is not positive that turbidity will be reduced

007. mixing of water temperatures above dams

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(4)	27%	0%	4%	4%	48%	11%	0%	2%	100%
#2	(4)	20%	0%	5%	0%	58%	14%	0%	0%	100%
#3	(4)	19%	0%	6%	0%	61%	12%	0%	0%	100%

Comment from Respondent

008. possible increase in erosion along shoreline of impoundment

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(5)	0%	0%	2%	2%	20%	51%	13%	9%	100%
#2	(5)	0%	0%	0%	2%	20%	61%	11%	2%	100%
#3	(5)	0%	0%	0%	3%	19%	64%	9%	3%	100%

Comments from Respondents

--depending on management
--can go either way depending on the site
--will ultimately need dredging and erosion controls
--erosion control management would be a high priority
--although there may be some shoreline erosion, there would also be some stream bank erosion if the impoundment was not installed. Therefore, I think that the additional erosion would be negligible.
--depends on management

009. change from shallow, flowing habitat to deep, still habitat

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(3)	18%	6%	23%	13%	20%	6%	2%	6%	100%
#2	(3)	20%	5%	26%	17%	17%	5%	2%	2%	100%
#3	(3)	19%	3%	25%	19%	22%	3%	3%	3%	100%

Comments from Respondents

--depends upon flora and fauna affected, good or bad
--depends on existing riverine populations and projected reservoir fishery (positive on reservoir fish species) (negative on river fish)
--positive impact on ephemeral streams; negative impact on perennial streams like the Niobrara and Loup Rivers
--(positive) Swanson Reservoir...(negative) Platte River migratory waterfowl

010. change in type of fish populations

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(2)	13%	23%	25%	6%	13%	6%	6%	2%	100%
#2	(2)	17%	26%	29%	5%	8%	0%	8%	2%	100%
#3	(2)	19%	22%	32%	6%	9%	0%	6%	3%	100%

Comments from Respondents

--depends on flora and fauna affected, good or bad
--in Nebraska this would probably change from a minnow-bullhead fishery to a sport fishery
--applies to ephemeral streams
--a reservoir fishery is not always better than a stream fishery although the volume may support more fishing trips
--(negative) endangered species
--most likely the streams affected will be high quality western streams

011. change in movement of fish populations

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(4)	20%	2%	16%	4%	18%	25%	6%	4%	100%
#2	(4)	29%	0%	17%	2%	17%	26%	2%	2%	100%
#3	(4)	25%	0%	16%	3%	22%	25%	3%	3%	100%

Comments from Respondents

--depends on flora and fauna affected, good or bad
--could affect migratory populations

012. change in silt and mud bottom community

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(5)	23%	0%	2%	6%	18%	32%	9%	6%	100%
#2	(5)	20%	0%	0%	5%	14%	47%	11%	0%	100%
#3	(5)	19%	0%	0%	6%	16%	51%	6%	0%	100%

Comments from Respondents

--detrimental if sand bottom species wiped out
--this again depends on the individual situation. A stream can also have a silt and bottom

013. change in emergent and submergent vegetation and related invertebrates and fish

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(4)	37%	2%	4%	11%	23%	9%	2%	9%	100%
#2	(4)	38%	2%	5%	14%	26%	2%	0%	8%	100%
#3	(4)	35%	3%	3%	19%	29%	0%	0%	9%	100%

Comments from Respondents

--depends on flora and fauna affected, good or bad
--not clearly understood on changes of vegetation
--Lake Maloney at North Platte is full of growth till motorboats will hardly function
--once again depends on existing riverine populations, can go either way
--should improve fishery

014. change in value of shallow areas to waterfowl and other wildlife due to fluctuations leading to possible sterile zone

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(5)	23%	0%	2%	2%	18%	23%	18%	11%	100%
#2	(5)	20%	0%	0%	0%	23%	26%	17%	11%	100%
#3	(5)	16%	0%	0%	0%	22%	32%	16%	12%	100%

Comments from Respondents

--what is sterile zone?
--uncertain about wildlife effects
--this would be significant to the waterfowl and wildlife
--my feeling is that this is not a negative impact because much riparian habitat remains
--shallow areas are usually the most productive spawning areas for fish and forage areas for shore birds. Management can make or break these areas

015. inundation of riparian habitat; shift from terrestrial to aquatic ecosystem

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(5)	16%	0%	18%	4%	16%	16%	11%	16%	100%
#2	(5)	14%	0%	20%	2%	14%	17%	11%	17%	100%
#3	(5)	12%	0%	16%	3%	16%	22%	12%	16%	100%

Comments from Respondents

--depends upon flora and fauna affected, good or bad
--riparian habitat is limited and unique in Nebraska because this is the only wooded areas in many parts of the state. Also there has been a steady loss of riparian habitat. Any additional loss is significant
--due to short supply of riparian habitat in Nebraska this would probably be negative
--the whole ecosystem would be changed
--we have plenty of riparian habitat
--Nebraska needs more aquatic ecosystems
--Needs to be considered on an individual site by site basis. Statewide, riparian is critical but in some local areas more diversity could be obtained by shifting to aquatic which yields a higher return.

016. loss of species; dislocation or shift in migration of species

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(5)	13%	0%	2%	11%	25%	18%	9%	18%	100%
#2	(5)	11%	0%	0%	8%	32%	14%	11%	20%	100%
#3	(5)	12%	0%	0%	6%	35%	12%	12%	19%	100%

Comment from Respondent

--the ecologists feel this is significant (whooping cranes and sandhill cranes)

017. increased public access and recreational use of area with related requirements for facilities for waste disposal, etc.

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(2)	4%	25%	34%	16%	0%	9%	9%	0%	100%
#2	(2)	2%	29%	41%	17%	0%	5%	2%	0%	100%
#3	(2)	3%	29%	45%	16%	0%	3%	3%	0%	100%

Comments from Respondents

--depends on recreational uses; full blown or primitive
--potential impacts vary widely depending upon site specific conditions and operation of impoundment
--public use determines quality

018. secondary impacts of land development in surrounding area

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(3)	9%	9%	27%	18%	4%	18%	6%	4%	100%
#2	(3)	5%	11%	29%	23%	2%	17%	5%	2%	100%
#3	(3)	9%	6%	25%	32%	3%	16%	3%	3%	100%

Comments from Respondents

--potential impacts vary widely depending upon site specific conditions and operations of impoundment
--assuming uncontrolled development of resort facilities
--generally, land values will rise in areas surrounding a surface impoundment, which I see as a benefit to those affected
--my first interpretation was more along the lines of housing, lots, etc., this interpretation is more on irrigation development, economic improvement
--as a biologist "land development" does not intrigue me
--environmentally negative, commercially positive
--depends on your viewpoint. From the viewpoint of the resource, probably negative; from the viewpoint of land owners, a positive economic return

019. change in visual quality from flowing stream and riparian environment to open water and open shoreline

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(4)	11%	6%	16%	18%	25%	9%	4%	6%	100%
#2	(4)	5%	8%	17%	20%	26%	5%	11%	2%	100%
#3	(3)	6%	3%	16%	29%	25%	6%	9%	3%	100%

Comments from Respondents

--applies to areas like the Platte where there is a large amount of floodplain habitat
--depends on location
--potential negative due to water level fluctuation
--personal choice
--this is a personal preference...Riparian habitat is limited and unique in Nebraska because this is the only wooded areas in many parts of the state. Also there has been a steady loss of riparian habitat. Any additional loss is significant.
--within reason, this can be a positive impact

2. Downstream impacts of diversions and downstream effects of impoundments

020. possible reduction and variability in downstream flows

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(5)	6%	6%	2%	6%	16%	16%	27%	16%	100%
#2	(6)	5%	5%	2%	5%	11%	17%	32%	17%	100%
#3	(6)	6%	3%	3%	3%	12%	22%	35%	12%	100%

Comments from Respondents

--below impoundment restricted flow
--assuming minimum releases from dam as is often the case to provide mitigation
--(positive) with storage for instream flows...(negative) without storage for instream flows
--I am interpreting this to mean reduction of high flows which cause some flooding, erosion and sedimentation and establishing a consistent release flow
--there is also a possiblity of a more uniform sustained flow, depends on design and operation

021. trapping of sediment upstream and varied downstream loading depending on management of flow

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(4)	9%	9%	16%	18%	6%	16%	18%	4%	100%
#2	(5)	8%	8%	11%	14%	8%	32%	11%	2%	100%
#3	(4)	6%	9%	9%	22%	6%	29%	12%	3%	100%

Comments from Respondents

--the west end of Lake MaConaughy is 3 miles of mudflats as is Midway lake south of Cozad
--(positive) water quality...(negative) channel degradation
--loss of sediment below dam will cause bank and bed scouring
--depending on purpose for which water is to be used, this can be either positive or negative
--reduction of downstream sediment is a very positive impact on both agriculture and aquatic life.
--this is another situation where both positive and negative impacts occur, but I think slightly negative

022. change in water quality in relation to amount of flow usually meaning a decline in water quality

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(5)	9%	0%	0%	9%	18%	25%	32%	4%	100%
#2	(5)	8%	0%	2%	5%	17%	29%	32%	2%	100%
#3	(5)	6%	0%	0%	6%	16%	35%	32%	3%	100%

Comments from Respondents

--assumption of decline in quality questionable; could as easily improve quality downstream
--when water quality declines the ecosystem declines
--downstream water quality should improve because of reduced sediment
--after reading the question again, no, it's a poor question. If flows are reduced there is a good change for decline of water quality.
--I am more uncertain about the question than the impacts.

023. change in area of floodplain; change in vegetation and habitat

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(3)	9%	13%	18%	20%	4%	9%	11%	11%	100%
#2	(3)	2%	11%	17%	32%	5%	14%	5%	8%	100%
#3	(3)	6%	9%	16%	38%	6%	9%	6%	6%	100%

Comments from Respondents

--again, it will depend on the purposes intended. I see little need for any more lacustrine habitat in this state; as a result, I would value more highly existing riparian habitats
--we are in a very limited floodplain area
--(effective floodplain) encroachment, restriction of floodplains area; inability to handle flood flows...(negative) with respect to physical-hydrological changes. Uncertain about effects on wildlife--possibly positive impacts
--allows human encroachment and vegetation establishment, flood damages may increase
--the change in floodplain could have negative or positive impact depending on site
--a reduced floodplain area means that more land is available for use without the risk of flood damage. Flood protection should be a major benefit
--a large flood will have more impacts on a restricted flood plain, small floods will have little impact.
--although reduced flooding is a benefit, flood damages continue to rise in spite of flood control efforts
--(positive) less flooding; (negative) loss of riparian habitat adjacent to river

024. change in water temperature below dam as an impact on fish and invertebrates

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(4)	20%	0%	6%	9%	37%	13%	2%	9%	100%
#2	(4)	20%	0%	5%	8%	47%	8%	2%	5%	100%
#3	(4)	19%	0%	0%	12%	48%	9%	3%	6%	100%

Comments from Respondents

--damage will occur when there are not releases; a maintained minimum flow could be beneficial.
--it would depend on the original temperature regime in the unaffected stream.
--In Nebraska there is probably no signficant impact, because reservoirs are generally rather shallow with no radical temperature gradients
--(positive) cold water fishing; (negative) increase in temperature

025. change in fish movement and spawning; barriers to upstream movement

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(6)	9%	2%	0%	2%	18%	20%	20%	25%	100%
#2	(5)	8%	2%	0%	0%	17%	32%	17%	20%	100%
#3	(5)	6%	3%	0%	0%	19%	32%	16%	22%	100%

026. possible change in recreation or other use of shoreline due to change in flow

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(4)	6%	4%	9%	13%	25%	16%	16%	6%	100%
#2	(4)	2%	2%	5%	20%	26%	17%	14%	8%	100%
#3	(4)	6%	3%	0%	22%	25%	25%	9%	6%	100%

Comments from Respondents

--I can only see improvement, if you change to regulated flows with impoundment areas.
--take the word "possible" out of the question and the average response might be different
--possibly positive
--when land rights are negotiated this is significant
--upstream diversions or impoundments would tend to stablize flows, therefore stablizing stream shorelines, having a positive effect on recreation
--(negative) Harlan County poor fishing but canoeing improved during summer months

027. change in visual quality due to reduced or varied flow in stream

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(5)	4%	0%	0%	2%	34%	32%	16%	9%	100%
#2	(5)	2%	0%	0%	0%	35%	44%	14%	2%	100%
#3	(5)	3%	0%	0%	0%	38%	41%	12%	3%	100%

Comment from Respondent

--possibly positive

B. Groundwater as a source of supply

1. Impacts of withdrawals of groundwater for transfer to location of use

028. decline in groundwater level in area of withdrawal

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(6)	6%	0%	0%	0%	2%	18%	32%	39%	100%
#2	(6)	2%	0%	0%	0%	0%	29%	26%	41%	100%
#3	(6)	3%	0%	0%	0%	0%	19%	41%	35%	100%

Comment from Respondent

--(positive)...site specific--areas of rapid recharge, withdrawals create storage space for capturing excess rainfall (negative)...in areas of deep aquifers slow recharge, withdrawals not replaced--loss of storage, restriction in future use

029. reduction in wetland areas in areas of high water table

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(6)	4%	2%	2%	0%	6%	25%	30%	27%	100%
#2	(6)	2%	0%	2%	0%	5%	32%	23%	32%	100%
#3	(6)	3%	0%	0%	0%	9%	32%	32%	32%	100%

Comments from Respondents

--wetlands are very valuable
--(positive) with respect to developed areas plagued by high water tables and intermittent wetland areas
(negative) with respect to wildlife, potential recreation.

030. change in habitat type related to groundwater declines and reduced areas of wetlands

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(6)	2%	2%	0%	0%	6%	27%	39%	20%	100%
#2	(6)	2%	0%	0%	0%	5%	32%	32%	26%	100%
#3	(6)	3%	0%	0%	0%	6%	32%	32%	25%	100%

Comments from Respondents

--uncertain about specific nature of biological impacts; presumably negative
--a change in habitat type is not necessarily bad.

031. reduction in streamflow related to groundwater withdrawals for transfer

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(6)	2%	0%	0%	0%	4%	25%	39%	27%	100%
#2	(6)	2%	0%	0%	0%	2%	23%	44%	26%	100%
#3	(6)	3%	0%	0%	0%	3%	25%	41%	25%	100%

Comment from Respondent

--site specific, time related

032. changes in vegetation and habitat as related to streamflow decline

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(5)	4%	0%	0%	0%	16%	37%	30%	11%	100%
#2	(5)	2%	0%	0%	0%	8%	52%	23%	11%	100%
#3	(5)	3%	0%	0%	0%	9%	54%	19%	12%	100%

Comments from Respondents

--a change in habitat type is not necessarily bad
--the impact depends on the magnitude of the streamflow decline. It makes no difference what causes the decline (surface or groundwater use). Questions should relate to magnitude of decline.

033. changes in land use related to groundwater declines, reductions in wetland areas and streamflow declines

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(6)	9%	2%	0%	6%	6%	25%	16%	32%	100%
#2	(6)	8%	0%	0%	2%	8%	32%	14%	32%	100%
#3	(5)	6%	0%	0%	3%	9%	35%	12%	32%	100%

Comments from Respondents

--site specific
--could improve crop production (corn, beans, etc); also could hurt alfalfa yield, habitat
--if dryland is changed to irrigated because of wells, then changed back to dryland because of ground water declines, there would be no net land use change
--leading question

II. Impacts Related to Transfer of Water

A. Canals

034. change in groundwater level from seepage from unlined canal

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(3)	6%	9%	34%	20%	6%	2%	13%	4%	100%
#2	(2)	5%	11%	38%	23%	5%	2%	11%	2%	100%
#3	(2)	9%	12%	35%	16%	6%	3%	12%	3%	100%

Comments from Respondents

--area affected limited if seepage from a single canal. Potentially negative impact in areas with already high water table.
--Dawson County depends on seepage from canals, drains are needed too. Changes would have immediate repercussions.
--we need groundwater recharge--seepage from canals is one way
--high water table problems in CNPP&I District and Ashton, Farwell area
--creates wetlands
--(positive) "create" wetlands; (negative) loss of wildlife habitat due to canal
--high water tables could be a possibility; it could also be beneficial for recharge.

035. change in flow of existing canal (if such is utilized)

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(4)	41%	0%	0%	6%	34%	11%	4%	0%	100%
#2	(4)	29%	0%	0%	2%	52%	14%	0%	0%	100%
#3	(4)	19%	0%	0%	3%	61%	16%	0%	0%	100%

Comment from Respondent

--greater ability to maintain proper flow for hydraulic conditions

036. change in water quality if mixing of old and ndw supplies occurs

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(4)	34%	0%	0%	9%	34%	18%	0%	2%	100%
#2	(4)	32%	0%	0%	5%	44%	17%	0%	0%	100%
#3	(4)	25%	0%	0%	6%	51%	16%	0%	0%	100%

Comment from Respondent

--dependent upon quantities and quality of 2 supplies (i.e., old and new) and intended use

037. loss of fish populations at intakes to canals

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(5)	9%	0%	0%	2%	25%	51%	6%	4%	100%
#2	(5)	11%	0%	0%	0%	23%	58%	5%	0%	100%
#3	(5)	9%	0%	0%	0%	22%	61%	6%	0%	100%

038. increase in hazards and restricted movement for wildlife

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(5)	4%	0%	0%	0%	20%	39%	30%	4%	100%
#2	(5)	5%	0%	0%	0%	20%	38%	32%	2%	100%
#3	(5)	6%	0%	0%	0%	19%	38%	32%	3%	100%

Comment from Respondent

--whooping crane fund $7 million

039. increase in safety hazards

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(5)	6%	0%	0%	0%	20%	48%	16%	6%	100%
#2	(5)	5%	0%	0%	0%	11%	67%	11%	2%	100%
#3	(5)	6%	0%	0%	0%	12%	64%	12%	3%	100%

Comments from Respondents

--I can see some small impacts here
--It depends whose safety is threatened

040. interference with access for farming and other activities

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(5)	4%	0%	0%	0%	13%	51%	23%	6%	100%
#2	(5)	5%	0%	0%	0%	5%	64%	20%	2%	100%
#3	(5)	6%	0%	0%	0%	6%	64%	19%	3%	100%

Comments from Respondents

--I can see some small impacts here
--this is significant when land rights are negotiated for

041. change in recreation opportunities due to presence of canal

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(4)	6%	0%	9%	20%	44%	13%	4%	0%	100%
#2	(4)	5%	0%	0%	20%	58%	8%	5%	0%	100%
#3	(4)	6%	0%	0%	19%	54%	12%	6%	0%	100%

Comment from Respondent

--Maybe I went overboard, but large canals in Nebraska (Loup Power Canal, Tri-County, etc.) do provide very significant recreational opportunities

B. Pipelines

042. change in habitat type; disruption of wildlife movement

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(4)	4%	0%	0%	0%	62%	23%	4%	4%	100%
#2	(4)	5%	0%	0%	0%	67%	26%	0%	0%	100%
#3	(4)	6%	0%	0%	0%	64%	29%	0%	0%	100%

043. short term disruption of human access and activities

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(4)	4%	0%	0%	2%	46%	41%	4%	0%	100%
#2	(4)	5%	0%	0%	0%	50%	44%	0%	0%	100%
#3	(4)	6%	0%	0%	0%	48%	45%	0%	0%	100%

Comment from Respondent (042-043 Pipelines)

--pipelines look good environmentally--"out of sight out of mind" but cost is tremendous--several million per mile to move signficant amounts of water

C. Existing streams

044. increase in flow with some variations from management of supply

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(3)	13%	9%	13%	27%	11%	13%	9%	0%	100%
#2	(3)	8%	8%	14%	38%	8%	14%	5%	0%	100%
#3	(3)	6%	6%	16%	45%	6%	12%	6%	0%	100%

Comment from Respondent

--this has been very beneficial in the Platte below the Tri-County project

045. change in water temperature in stream

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(4)	23%	0%	4%	2%	51%	11%	4%	2%	100%
#2	(4)	20%	0%	5%	0%	61%	5%	5%	0%	100%
#3	(4)	16%	0%	3%	3%	64%	6%	6%	0%	100%

Comments from Respondents

--if low flow is higher, then annual maximum water temperature will likely be lower which will allow more dissolved oxygen
--no more trout if it gets warmer
--up or down?

046. change in other water quality factors as mixing of water occurs

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(4)	23%	0%	4%	9%	37%	20%	2%	2%	100%
#2	(4)	20%	0%	2%	8%	41%	26%	0%	0%	100%
#3	(4)	16%	0%	0%	9%	45%	29%	0%	0%	100%

Comment from Respondent

--could go either way

047. possible increase in erosion along streambank

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(5)	0%	0%	0%	2%	20%	44%	23%	9%	100%
#2	(5)	0%	0%	0%	0%	20%	50%	20%	8%	100%
#3	(5)	0%	0%	0%	0%	16%	54%	19%	9%	100%

048. change in vegetation and fish and wildlife populations as related to above

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(4)	18%	0%	0%	13%	32%	23%	4%	6%	100%
#2	(4)	11%	0%	0%	11%	41%	23%	2%	8%	100%
#3	(4)	9%	0%	0%	9%	48%	19%	3%	9%	100%

Comments from Respondents

--probably not a good question
--(positive) flows maintained during droughts;
  (negative) reparian habitat lost
--depends on flow regime

D. Induced Recharge

049. impacts of increase in underground water level

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(2)	6%	23%	46%	16%	2%	2%	2%	0%	100%
#2	(2)	2%	23%	61%	11%	0%	0%	0%	0%	100%
#3	(2)	3%	25%	61%	9%	0%	0%	0%	0%	100%

Comment from Respondent

--for water supply (positive)

050. possible decline in streamflow

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(5)	9%	0%	0%	2%	9%	37%	27%	13%	100%
#2	(5)	8%	0%	0%	0%	8%	38%	35%	8%	100%
#3	(6)	9%	0%	0%	0%	6%	38%	35%	9%	100%

Comments from Respondents

--I would think that streamflow would increase in the area of induced recharge
--site specific

III. Impacts in area of storage and use

A. Surface water storage

1. On-Channel Impoundments on flowing streams--assumed to have same impacts as noted in section I.A., items 001-027, plus the following:

051. change in water quality due to mixing of new and existing supply

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(4)	25%	0%	4%	20%	37%	6%	4%	0%	100%
#2	(4)	20%	0%	5%	17%	47%	5%	2%	0%	100%
#3	(4)	9%	0%	3%	22%	54%	6%	3%	0%	100%

052. change in water temperature

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(4)	25%	0%	2%	9%	48%	9%	2%	2%	100%
#2	(4)	17%	0%	2%	8%	58%	5%	5%	0%	100%
#3	(4)	12%	0%	3%	9%	61%	6%	6%	0%	100%

053. change in sedimentation in mixed supply

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(4)	16%	0%	0%	11%	37%	27%	6%	0%	100%
#2	(4)	3%	0%	3%	13%	40%	33%	6%	0%	100%
#3	(4)	3%	0%	0%	12%	48%	32%	3%	0%	100%

2. Off-Channel Impoundments

054. inundation of terrestrail vegatation and habitat

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(5)	6%	0%	0%	4%	18%	37%	16%	16%	100%
#2	(5)	2%	0%	0%	0%	25%	38%	17%	17%	100%
#3	(5)	3%	0%	0%	0%	19%	45%	16%	16%	100%

Comment from Respondent

--any large impoundment is going to have a significant impact especially if it is on prime agricultural land

055. wide variation in water level due to management and use

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(5)	2%	0%	2%	2%	20%	27%	32%	11%	100%
#2	(5)	2%	0%	2%	0%	20%	29%	38%	5%	100%
#3	(5)	0%	0%	0%	0%	22%	32%	38%	6%	100%

Comment from Respondent

--with respect to other uses (recreation, etc.) assume to be at point of use (negative)

B. Ground water storage

1. By surface spreading of new water

056. change in aquifer storage

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(2)	9%	25%	27%	23%	9%	2%	0%	2%	100%
#2	(2)	11%	32%	38%	11%	5%	0%	0%	0%	100%
#3	(2)	9%	32%	41%	9%	6%	0%	0%	0%	100%

Comments from Respondents

--(positive) increase
--positive impact--site specific; negative impacts if water table already high

057. possible water-logging of land

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(5)	6%	0%	2%	6%	11%	34%	20%	16%	100%
#2	(5)	8%	0%	0%	5%	11%	44%	11%	17%	100%
#3	(5)	6%	0%	0%	6%	9%	48%	12%	16%	100%

Comments from Respondents

--however this would benefit wetlands and wildlife
--creates wetlands/good for environment
--could be prime agricultural land
--I've seen too much of it to go to a lower #(6)

058. increase in evaporation

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(5)	13%	0%	2%	11%	27%	30%	13%	0%	100%
#2	(5)	11%	0%	0%	5%	32%	38%	11%	0%	100%
#3	(5)	9%	0%	0%	3%	35%	38%	12%	0%	100%

Comments from Respondents

--again, I think the effect of evaporation is underestimated
--benefit the air

059. change in water temperature; physical and chemical quality

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(4)	27%	0%	4%	4%	39%	16%	6%	0%	100%
#2	(4)	20%	0%	5%	5%	44%	14%	8%	0%	100%
#3	(4)	9%	0%	3%	9%	58%	9%	9%	0%	100%

Comments from Respondents

--potentially very significant
--includes nitrate problems

060. sedimentation which may require treatment if source of supply is surface water

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(5)	13%	0%	0%	0%	13%	46%	20%	4%	100%
#2	(5)	11%	0%	0%	0%	5%	58%	17%	5%	100%
#3	(5)	9%	0%	0%	0%	9%	58%	19%	3%	100%

061. microbial growth possible if surface water source

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(5)	37%	0%	0%	2%	20%	20%	11%	6%	100%
#2	(5)	35%	0%	0%	0%	23%	20%	14%	5%	100%
#3	(5)	25%	0%	0%	0%	32%	25%	12%	3%	100%

Comment from Respondent

--impact on aquifer

062. displacement of other land uses

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(5)	16%	0%	0%	2%	16%	44%	11%	9%	100%
#2	(5)	14%	0%	0%	0%	17%	47%	14%	5%	100%
#3	(5)	12%	0%	0%	0%	19%	45%	16%	6%	100%

Comments from Respondents

--from agricultural to wildlife land. A minus for land users and a plus for wildlife
--may be on prime agricultural land

2. By injection wells

063. impact of new water on quality of existing supply-compatibility

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(5)	44%	0%	4%	4%	18%	11%	9%	6%	100%
#2	(4)	38%	0%	2%	8%	23%	14%	5%	5%	100%
#3	(4)	32%	0%	0%	6%	32%	16%	6%	6%	100%

Comments from Respondents

--must be a subject no one knows anything about
--from a user perspective I would rate this a 4; however, technically well injection normally experiences serious problems of lack of compatibility which plugs the wells
--the worst thing that can happen is to pollute ground water
--quality of injected water may have severe impact on operation of injection well; impact on aquifer water quality secondary

064. change in aquifer storage characteristics

Delphi Round	Median Score	Percent Distribution of Responses (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Totals**
#1	(4)	30%	2%	16%	16%	20%	6%	2%	4%	100%
#2	(4)	26%	2%	20%	11%	23%	8%	2%	2%	100%
#3	(4)	16%	3%	16%	9%	38%	9%	3%	3%	100%

Comments from Respondents

--must be a subject no one knows anything about
--increased volume in storage
--sedimentation of the aquifer
--there is more chance for aquifer storage characteristics to be impacted negatively than positively from injection of water, expecially silty surface water

General Comments

- These questions are very broad and answers could also have a wide variation due to varying local conditions
- Reservoirs or transfers from the Niobrara River would have considerably different impacts than water projects from the Platte River south Division by geograph area would change many of my answers
- I feel many of the questions or situations have several answers all of which depend on the individual's interpretation of the question. I think there is a lot of vagueness with each item. You say this is for "possible supplemental water supply projects" but many of the questions asked appear to be answerable more for existing projects. In #3 seepage into the surrounding aquifer may be part of a project design and may be a significant positive impact on maintaining groundwater levels or it could be negative if this is not part of the design. In #12 what is meant by the question? Most rivers are silt and mud bottomed. A reservoir would surely improve the turbidity of the water in the reservoir but a canal diverting from an existing silt and mud bottomed river would be running through silt and mud bottomed locations so there would be no change in the water. I think I could question each item in some manner which may swing the pendulum.

Evaluation

A review of the results indicated that the bulk of the median responses are in item 4 "no significant impact" and item 5 "limited negative impact". These were also the median responses accompanied by the largest number of "0" uncertain of impact" responses. The following table illustrates the distribution of median responses with greater than 15% "uncertain of impact" responses.

Median	Distribution in rounds 1,2,3 by item	% of total medians (rounds 1,2,3)	Incidence of items with greater than 15% "uncertain of impact" by medians	Percent
1	0	0	0	0
2	16	8.33	2	3.7
3	18	9.33	3	5.5
4	65	33.85	37	68.5
5	75	39.06	12	22.2
6	18	9.33	0	0
7	0	0	0	0
Total	192	100%	54	100%

This overall distribution suggests that stronger statements of positive or negative impact are not associated with a significant incidence of "0" "uncertain of impact" responses, at least as reflected in the median score distribution.

A first "pass" through these results focuses on items at both ends of the scale — those with median responses of "6" "moderate negative impact" and "2" "moderate positive impact".

Items with medians of "6" include

020 **possible reduction and variability in downstream flows**
(round 2,3 only)

025 **change in fish movement and spawning; barriers to upstream movement**
(round 1 only)

028 **decline in groundwater level in area of withdrawal**

029 **reduction in wetland areas in areas of high water table**

030 **change in habitat type related to groundwater declines and reduced areas of wetlands**

031 **reduction in streamflow related to groundwater withdrawals for transfer**

033 **changes in land use related to groundwater declines, reductions in wetland areas and streamflow declines**
(rounds 1,2 only)

050 **possible decline in streamflow (induced recharge)**
(round 1 only)

It is evident the larger share of items with a median of "6" reflecting a fairly strong estimation of negative impact are associated with the transfer and possible drawdown of groundwater supplies. Percent of "0" "uncertain of impact" responses was low (below 10%) on all of these items, while percent of "7" "significant negative impact" responses were over 20% on the groundwater items and on 025.

Items with medians of "2" include

003 **hydrologic impact on aquifers due to storage in impoundments; possible seepage**
(rounds 2,3 only)

010 **change in type of fish populations**

017 **increased public access and recreational use of area with related requirements for facilities for waste disposal, etc.**

034 **change in groundwater level from seepage from unlined canal**
(rounds 2,3 only)

049 **impacts of increase in underground water level**

050 **change in aquifer storage**

These items reflecting the strongest estimates of positive impact are more widely distributed as to types of activities, but still reflect a significant concern with groundwater. But surface water development and transfer (003, 010, 017, 134) and storage of groundwater (049, 056) are activities associated with these potential effects. Item 10 was characterized by responses of "0" "uncertain of impact" at 13%, 17% and 20% for rounds 1,2,3.

Items 049 and 056 had over 25% "1" "significant positive impact" responses on all three rounds.

A second "pass" through these results reviews the responses on a section by section basis according to the type of supply and activity (impoundment, etc.) and area of impact.

Impacts In Area of Source of Supply

Surface Water as Source of Supply

Impacts of Impoundments (items 001 to 019)

The possible effects of the development of impoundments in areas of the source of surface water supply (presumably flowing streams) illustraed varying assessments of what was positive and what was negative impact, varying estimates of the influence of eventual management practices on impacts, and in some cases an estimation that either positive or negative effects could take place depending on location and other factors. Uncertainty in predicting general outcomes may have also influenced the responses. Different perspectives toward the systems at work (biological and hydrological) may have been a factor as well.

Changes in habitat appeared to elicit disagreement as to the significance of their impact. On some items responses were spread across positive and negative scores. On many a substantial percent estimated "no significant impact" while significant percentages of respondents estimated either positive or negative impacts. Development, use and accessibility were seen as positive as were some habitat changes and hydrologic impact on aquifers. Eight items had median scores of "5" "limited negative impact". The remainder of median scores reflected judgements of "no significant impact" ("4").

Downstream impacts of diversions and downstream effects of impoundments (items 020 to 027)

These downstream effects illustrated some disagreement as to the extent of impact of particular changes. The most significant positive assessment was on item 023 which dealt with changes in the vegetation and habitat of the floodplain. A bimodal and spread out response pattern, both positive and negative, characterized item 021 which dealt with the effects of trapping sediment upstream. Change in recreation and effects of change in water temperature illustrate divided responses. Effects on streamflow itself, water quality and visual quality were given moderately negative assessments (median scores). Overall, the possible variability in outcome, the perception lack of dramatic

potential changes due to few coldwater streams, the significant influences of management of flows, and simultaneous positive and negative effects moderate these estimations and moved most of them toward the middle of the scale.

Groundwater as a source of supply

Impacts of withdrawals of groundwater for transfer to location of use (items 028 to 033)

As noted above, this block of items was estimated as the most negative in potential impact. All had median scores of "6" "moderate negative impact", except 032 (changes in vegetation and habitat as related to streamflow decline) which had a median score of "5" "limited negative impact". There was almost no positive ranking of any of these impacts, except for 3% on one item. These likely reflect a consensus and more uniform perception about the possible effects of major changes related to reductions in groundwater supply.

Impacts related to Transfer of Water
(items 034 to 050)

These items examine a range of means of transferring water. Increases in groundwater supplies from seepage or induced recharge are estimated generally as positive effects. Disruptions in human activities (039, 040) and loss of fish and increased hazard for wildlife (037, 038) are seen as negative in relation to canals. Other biological effects of canals were viewed as not having significant effect, although with some uncertainty and a share of negative rankings. Pipelines were estimated as more moderate in their effects, but with a share of negative rankings. Use of existing streams elicited positive estimations as to increased flow, negative in relation to possible increased erosion and median rankings of "4" "no significant impact" on several items related to water temperature, quality and vegetation. Overall, activities leading in increases in supply or flow of water or related human activity were often assessed as positive in their effect. Negative items were not as clearly ranked as the groundwater items noted above, although safety and disruption in relation to human activities achieved fairly strong and closely grouped rankings.

Impacts In area of storage and use

Surface water storage

(items 051 to 055 plus 001 to 027)

On-Channel impoundments on flowing streams
(051 to 053)

Each of these items had a median score of "4" "no significant impact", and only the item related to sedimentation (053) was skewed significantly to the negative. These items should be seen as additions to 001 to 027.

Off-Channel impoundments (054 to 055)

Both of these items were assessed negatively ("5") with no positive rankings. These estimations appeared to reflect the basic change in use and natural systems where inundation takes place and the effects of necessary variation in water level.

Groundwater Storage

By surface spreading of new water
(056 to 062)

By injection wells
(063, 064)

These items reflect assessment of technologies which have only been used experimentally in Nebraska with respect to supplemental water supply development. Many of the items presented are closer to technological constraints than environmental impacts or constraints. The only impact assessed as positive was the change in aquifer storage brought about by surface spreading (056). All other impacts were assessed as negative (medians of "5" "limited negative impact") except for items 059 change in water temperature; physical and chemical quality, 063 (rounds 2,3) impact of new water on existing supply-compatability and 064 change in aquifer storage characteristics. These median rankings of "4" "no significant impact", although they also revealed both positive and negative assessments. These assessments may reflect concern for the quality of groundwater supplies combined with some uncertainty as to the positive and negative attributes of these activities; particularly in relation to chemical quality of water, operating costs in terms of displacement of land uses, evaporation and other concerns.

Conclusion

As stated, these items and the related median score, comments and distributions of responses and the preceding discussions represent attempts to evaluate the type of effect and degree of effect of a set of general categories of activities within the physical arena of the entire state of Nebraska. This effort was conducted within a communication process established around a pattern of interaction between respondents and the surveyor using the Delphi methodology. There were likely some gaps in this communication reflected in problems of the design, or statement of some questions and the different perspectives of respondents. Yet some conclusions can be drawn from this process.

First, there are genuinely differing perspectives as to the effects of surface water development and storage in certain areas of impact. These reflect differing evaluation of quality of habitat, of the management of surface water supplies an dof significant geographical differences and potentials.

Second, there appears to be a closer consensus on the major impacts of reductions in groundwater supplies in the area of reduction. These effects are more clearly seen as negative.

Third, modes of transportation and programs of groundwater storage are seen as possibly negative in effect or problematic in some but not all of their aspects.

These generalizations should not limit the necessary review of these impcts, item by item particularly including the transcribed comments. These represent the most significant aspects of the assessment and they cannot be fully synthesized into tables or general comments.

Acknowledgements and Responsibilities

The survey was made possible by the valuable assistance of Bob Burns (management), Tom Cech (computer work) and Danita Bright (typing/composition), all of the Water Resources Center. The product remains the responsibility of the surveyor, Charles Deknatel, Dept. of Community and Regional Planning, UNL.

Notes

1. The Delphi Technique

The Delphi technique was developed by the Rand Corporation in the 1950's for purposes of applying expert opinion to questions of stategic military importance.

Its early use as a tool for "technological forecasting"—estimating the extent and timing of technological developments—was expanding during the 1960's. The use of Delphi has expanded further as a means of estimating or developing consensus on complex issues and exploring future conditions. The technique has become more of an "heuristic" or explanatory device than strictly a means of measuring opinion. The critics of Delphi argue that it does not measure up to other behavioral science techniques in this regard. Others stress the value of Delphi as a communication process and see it as a technique of "last resort" to deal with problems not amendable to precise analysis.

Delphi is defined by Linstone and Turoff as a "method of structuring a group communication process so that the process is effective in allowing a group of individuals as a whole to deal with a complex problem". (1) It is also characterized by "controlled feedback" and often repeated rounds of consultation or survey with results provided to the respondent to provide an opportunity for reconsideration.

Typically a Delphi survey includes: research to define questions for the panel, identification of one or more panels of respondents, one or more rounds of questions and responses with feedback provided on the distribution of responses on each item and analysis of the results as to their degree of consensus, predicition, or exploration and mutual education on a complex issue.

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Notes

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APPENDIX D*

by

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* *This Appendix was written before the 1983 legislative session and does not reflect LB 21, LB 198 or any other bills passed during that session.*

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APPENDIX D

NEBRASKA LAWS AFFECTING SUPPLEMENTAL WATER SUPPLIES

LEGAL CONSTRAINTS

Many of the legal requirements described in this appendix appear to constrain supplemental water supply development by e.g. requiring that a permit be obtained or that a permit holder be legally liable for any damages caused to another water right holder. As will be seen, however, these apparent constraints actually facilitate such development by clarifying the developer's water rights and by removing some of the primary objections to supplemental water supply development. In general, the most serious legal constraints in Nebraska water law exist where inadequate or not legislative authorization is available to implement certain supplemental water supply alternatives. Most notable in this regard are the lack of authority for underground water storage and for agricultural groundwater transfers. The remaining "legal constraints" usually serve an important socio-political objective in accommodating those who are adversely affected by implementing a particular supplemental water supply alternative.

I. SURFACE WATER APPROPRIATION REQUIREMENTS

A. LEGAL REQUIREMENTS

1. Natural flow appropriations.

General procedures. Any person intending to appropriate surface water for any beneficial purpose must obtain an appropriation permit from the Nebraska Department of Water Resources (DWR). Neb. Rev. Stat. sec. 46-233. The appropriation can be granted if the DWR director determines that unappropriated water is available and that the appropriation would not be detrimental to the public welfare. **Id**. sec. 46-235. If the appropriation is granted, the appropriator must perfect his appropriation by applying water to a beneficial use. **Id**. sec. 46-239.

Interbasin transfer appropriations. Surface water from one river basin may be appropriated for storage or use in another river basin if unappropriated water is available and the proposed appropriation is not detrimental to the public welfare. **Id**. sec. 46-235. The interbasin transfer appropriation can be granted (after considering the economic and environmental costs and benefits of the proposed appropriation and water supply alternatives) if the benefits to the state of granting the application outweight the benefits to the state of denying the appropriation. **Id**. sec. 46-289. The specific criteria required to be considered in making this public interest determination are: (1) the economic, environmental, and other benefits of the proposed interbasin transfer and use; (2) any adverse impacts of proposed interbasin transfer and use; (3) the current and reasonably forseeable beneficial uses of water in the basin of origin; (4) the economic, environmental and other benefits of leaving the water in the basin of origin for current or future beneficial uses; (5) alternative sources of water available to the applicant; and (6) alternative sources of water available to the basin of origin for future beneficial uses. **Id**. Beneficial uses are defined to include but not to be limited to the reasonable and efficient use of water for domestic, municipal, agricultural, industrial, commercial, power production, subirrigation, fish and wildlife, groundwater recharge, interstate compact requirements, water quality maintenance, or recreational purposes. **Id**. sec. 46-288.

2. Storage appropriations.

Procedures. A person or entity may apply for a supplemental appropriation from a lake or reservoir to irrigate land served with a natural flow appropriation if streamflow is not always available for irrigation. **Id**. sec.46-240. Any person intending to appropriate surface water to store the water in a reservoir must follow the same appropriation procedures as for natural flow appropriations, described above at I(A)(1).

Natural flow preference. Storage appropriators are subject to the rights of junior natural flow appropriators during the irrigation season, even if the storage appropriation is the senior appropriation. The storage appropriator must release from the reservoir an amount of water up to reservoir inflow if the water is needed

by any downstream natural flow appropriator, regardless of their relative priorities. This requirement forces storage appropriators to store water during the non-irrigation season.

3. Reservoir construction.

A DWR permit is required to construct a reservoir to store surface water for any beneficial purpose. **Id.** secs. 46-241(1), 46-257. Reservoir owners are liable for damages caused by leakage or overflow from the reservoir. **Id.** 46-241(2).

4. Storage use appropriations.

Any person intending to use water stored in a reservoir obtain a DWR permit. **Id.** sec. 46-242. A person or entity other than the storage appropriator must provide documentary evidence that he is entitled to receive water stored in the reservoir, e.g. by contract. **Id.**

B. EVALUATION.

The appropriation requirements described above establish a procedure that potential appropriators must follow. These appropriation requirements do not generally constrain supplemental water supply development, as the purpose of the appropriation process is to clarify the rights of appropriators to use water. In this way the general appropriation process facilitates the development of supplemental water supplies. However, the specific features of the appropriation process discussed below may constrain supplemental water supply development.

1. Public interest criterion.

All appropriations must be determined by the DWR director to be in the public interest before the appropriation can be granted. While the director traditionally has not made an independent determination regarding whether a particular appropriation is in the public interest, the public interest criterion does give project opponents an opportunity to contest the application. This opposition may raise the cost of obtaining an appropriation by requiring the applicant to defend its appropriation in public hearings against objections raised by project opponents. Objectors may also appeal the director's decision in court, forcing the applicant to bear the additional cost of litigating the application before the Nebraska Supreme Court. In recently contested applications these procedural costs have been substantial, even leading to unsuccessful legislative attempts to streamline the application process. An advantage of this procedure, however, is that it does give project opponents ample opportunity to publicly identify problems or shortcomings of the proposed project before an irrevocable decision to complete the project has been made.

In addition to the procedural costs imposed, the public interest criterion may also establish substantive criteria constraining supplemental water supply development. For example, if two proposed supplemental water supply projects are applying for the same water, the DWR director (or the Nebraska Supreme Court on appeal) may determine that the public interest is better served by allocating the water to project A instead of to project B. This application of the public interest criterion constrains the development of particular supplemental water supply projects, but does not necessarily constrain supplemental water supply development generally (except for the procedural costs described above). More significantly, however, the DWR (or the Supreme Court) could determine that a proposed project was not in the public interest because it better interfere with environmental or other water uses which better served the public interest. If a porposed project's costs exceeded its benefits, the DWR (or Supreme Court) could similarly determine that the project was not in the public interest, even if there were no competing water use. Either of these application of the public interest criterion circumstances could constrain individual supplemental water supply projects and supplemental water supply development generally. This does not imply, however, that these constraints are necessarily inappropriate public policy.

2. Interbasin transfer appropriations.

For inbasin appropriations the term "public interest" is not legislatively defined. The term has been defined for interbasin transfer surface water appropriations, however. Interbasin transfer statutes require the DWR director to make an independent determination that the appropriation would be in the public interest determination. An interbasin transfer appropriation must be denied if the director finds (after evaluating the economic and environmental costs and benefits of the proposed appropriation and water supply alternatives) that the benefits to the state as a whole from denying the applicant are greater than the benefits to the state as a whole from granting the application. This application of the public interest criterion may constrain supplemental water supply development insofar as projects which would benefit some people are undertaken because their negative impacts outweight their benefits.

Appropriateness of the Public Interest Criterion. In the absence of a public interest or similar requirement, appropriations could be granted if they benefited the applicant. This approach would maximize the opportunity for supplemental water supply development. This approach would also ignore that the costs and benefits of such development are often disassociated—that one person's benefit may be another person's cost—and that in some cases such costs may outweigh the benefits of supplemental water supply development.

Liability for reservoir damage. Reservoir owners are legally liable for damages caused by leakage or overflow from the reservoir. This legal liability may be viewed as constraining supplemental water supply development, as this is a cost of such development imposed on the developer rather than on others. However, the requirement that this cost of supplemental water supply development be internalized (i.e. borne by the reservoir owner) may facilitate such development: those who would oppose the project because of potential injury from reservoir leakage or overflow may not oppose the project as strongly knowing that project developers will be liable for damages arising from reservoir leakage or overflow.

Natural flow preference. During the irrigation season natural flow appropriators may divert water which otherwise would be appropriated by senior storage appropriators. The purpose of this requirement is to force off-season storage during years of low flow. This requirement constrains supplemental water supply development in that storage project developers cannot depend on water being available for storage during the irrigation season: even though adequate water may be available when the project is initiated, the project's summer storage rights may be in effect divested by junior natural flow appropriators.

II. STORING WATER UNDERGROUND

Water can be stored underground, either deliberately (e.g. through injection wells) or incidentally to a surface water storage project (e.g. seepage from canals and laterals, and deep percolation from irrigated land). However, rights to store water underground and right to use water stored underground have not been directly legally addressed in Nebraska. A related issue, also not addressed, is whether surface water appropriations can be modified to reflect the unanticipated development of project recharge (i.e. incidental underground water storage).

A. GROUNDWATER RECHARGE RIGHTS AND DUTIES

A major legal issue related to storing water underground is who has the right to use underground storage capacity. Must a landowner be compensated if someone stores groundwater his land even if he is not harmed by the recharge activities? Can a landowner prevent a recharge entity from storing water under his land? If someone's property is flooded or the use of the property otherwise interfered with, is the recharge entity liable for damages?

1. Rights to store water underground.

Rights to store water underground have not been legally defined in Nebraska. One commentator has suggested that where rights to use groundwater are based on owning land overlying the aquifer, groundwater storage rights are private. Thorson, **Storing Water Underground: What's the Aqui-fer?** 57 Neb. L. Rev. 581, 593-601 (1978). This means that landowners must be compensated for the use of underground storage capacity, even in the absence of actual damages. Thorson further suggests that if groundwater is publicly owned, groundwater storage rights would be public also. The difference between public and private groundwater storage rights is that if they are private, landowners would be entitled to compensation for the use of their storage capacity even in the absence of actual damages (i.e. interference with surface uses). If groundwater storage rights are public, however, a landowner would not be entitled to compensation for the use of underground storage capacity unless actual damage occurred.

Nebraska does not fit neatly into this analytical framework. While groundwater rights are overlying (i.e. based on owning land overlying the aquifer) the Nebraska Supreme Court has ruled that groundwater is publicly owned. *State ex rel. Douglas v. Sporhase*, 208 Neb. 703 (1981). A court could rely on the overlying rights aspect of Nebraska groundwater law to require compensation of overlying landowners for their groundwater storage rights. Alternatively, a court could rely on the public ownership to rule that overlying landowners were not entitled to compensation in the absence of actual damages.

2. Liability for damages caused by storing water underground.

If storing water underground interferes with overlying (surface or subsurface) uses, such as flooding a basement or field, what liability does the recharge entity have? This is not addressed directly in Nebraska law, although owners of surface water storage reservoirs are "liable for all damages arising from leakage or overflow therefrom." Neb. Rev. State. sec. 46-241(2). The statute does not address liability for damages resulting from deep percolation beneath irrigated lands or from canal seepage. However, the storing entity is likely to be liable for any damages it causes through its recharge activities, even in the absence of a statute fixing liability.

B. RIGHTS TO WITHDRAW WATER STORED UNDERGROUND.

When water is stored underground can it be withdrawn and used according to general state groundwater law? Is the recharge entity entitled to compensation if recharged groundwater is withdrawn? Is the recharge project operator entitled to control the withdrawals of recharged groundwater? None of these issues have been addressed legally in Nebraska.

1. Common law.

Nebraska groundwater statutes and court decisions do not distinguish between groundwater that is stored underground "artificially" (e.g. through a recharge project) and groundwater that is "naturally occuring". Thus, a court could rule that a landowner is entitled to withdraw any groundwater underlying his land, regardless of its source, so long as the withdrawals and use otherwise were otherwise legal. Alternatively, surface water law precedents could be interpreted as giving an exclusive right to recapture recharged groundwater to recharge entities. Surface water project operators are generally entitled to recapture project waste and seepage water for reuse before such water escapes the project operator's control. 2 Hutchins, **Water Rights Laws in the Nineteen Western States** 568-85 (1974). If this theory were applied to a recharge project the major legal issue would be whether the project operator had abandoned the water stored underground, or whether it intended to (and was physically able to) recapture the water in the future. If the court were persuaded that these conditions were met it could rule that the recharge project operator had an exclusive right to recapture recharged groundwater. This legal theory could be used where indirect project recharge occurs incidentally to a federal reclamation project. 53 Cal. L. Rev. 541 (1965).

Nebraska Supreme Court decisions suggest that the court might be inclined to recognize a right a recharge project operators to control the withdrawals of water stored underground. The court has adopted parts of the correlative rights rule of groundwater law developed by the California Supreme Court. One facet of the correlative rights doctrine not yet addressed by the Nebraska Supreme Court is the right of recharge entities to control the withdrawal of water stored underground. Aiken, **supra**, at 933-34. Because the court has adopted other features of the correlative rights doctrine, it might be predisposed to adopt this feature as well.

2. Statutes.

Groundwater recharge is recognized to a limited extent in the public water supplier statutes and in reclamation district statutes. These statutes may imply a right to control water stored underground by a public water supplier or by a reclamation district.

Public water suppliers. A Department of Water Resources (DWR) permit may be obtained by public water suppliers to transfer groundwater or to recharge groundwater supplies. Neb. Rev. Stat. sec. 46-638(1). Public water suppliers are defined as public districts (natural resources districts, irrigation districts, reclamation districts, municipalities, etc.) supplying water to urban or rural areas for domestic or municipal water supply purposes. **Id**. sec. 46-638(2). The Act deals primarily with groundwater transfers for public water supply purposes. The recharge provisions are not extensive and appear to have been added as an afterthought (probably because the city of Lincoln had a small recharge project). Possession of a DWR recharge permit would allow a public water supplier to argue that by implication it had a right to control the withdrawals or water stored underground. The permit does not explicitly grant this right of control, however.

Reclamation districts. Reclamation districts are authorized to levy a charge of up to seven cents per $100 actual value (two mills) against land within the district receiving groundwater recharge benefits but not being irrigated with district surface water. **Id**. sec. 46-544. However, districts are not directly authorized to enjoin groundwater withdrawals if recharge assessments are not made. **Cf. Id.** 46-560(1).

C. MODIFYING A SURFACE WATER APPROPRIATION TO REFLECT THE OCCURRENCE OF UNDERGROUND WATER STORAGE.

In parts of Nebraska groundwater recharge is occurring as a part of surface water irrigation projects. Groundwater supplies are being recharged from irrigation canal seepage and from deep percolation from land irrigated with project water. In some cases this has led surface water irrigators to stop purchasing project surface water in favor of using recharged groundwater. This has two major consequences: (1) irrigators now using groundwater instead of project surface water are in effect forcing the project operation and maintenance cost onto the remaining irrigators purchasing project surface water; and (2) the project operators run the risk of having their surface water appropriations cancelled to the extent that less land is directly irrigated with project surface water has been reduced. The latter issue raises the question of whether the project operators could request the Department of Water Resources (DWR) to modify their appropriations to reflect the occurrence of groundwter recharge in order to avoid appropriation cancellation proceedings.

Under existing Nebraska law no means exist to allow a surface water appropriation to be modified to reflect the occurrence of project recharge. This means that if surface water users abandoned appropriated surface water in favor of recharged groundwater and the DWR had reason to believe that surface water had not been used pursuant to an appropriation for more than three years, the DWR must initiate administrative cancellation hearings. Neb. Rev. Stat. secs. 46-229 to -229.05. At the cancellation hearing appropriators would have the opportunity to "show cause" why the appropriation should not be cancelled. The project operators could argue that the water was being used by groundwater irrigators and that the appropriation should be modified accordingly. If the DWR agreed, no further action would be necessary. If the DWR disagreed, however, the quantity of water appropriated would be

reduced, in some cases up to 75%. This could make it difficult for some project operators to continue operations. Also, the source of recharge would be lost as surface water deliveries were reduced or stopped, which could lead to groundwater depletion.

Whether the DWR would have the legal authority to modify the appropriation to reflect the occurrence of project recharge is unclear. If, at the cancellation hearing, the DWR determined that the water appropriated was not used benefically for more than three years, the DWR must cancel the appropriation unless the nonuse was somehow excused. The issue would be whether the DWR would recognize the project recharge and use of water stored underground as a beneficial use of surface water.

D. EVALUATION

Nebraska water statutes do not address groundwter storage in a manner similar to surface water storage. This legal vacuum severely constrains deliberate attempts to store water underground, in that recharge project operators have no legal security in being able (1) to control withdrawals of water stored underground or (2) charge for its withdrawal. A related issue is the status of surface water appropriations when water appropriated for direct irrigation is instead stored underground. A final issue relates to liability for private damages resulting from storing water underground. These significant legal constraints to storing water underground could be addressed through legislation identifying underground water storage rights, duties, and authorities, and establishing procedures for modifying surface water appropriations to reflect the occurrence of underground water storage.

III. GROUNDWATER TRANSFERS

Nebraska statutes do not generally authorize groundwater transfers, i.e. the transportation of groundwater off-site for use at another location. The Nebraska Supreme Court has stated that the common law rights of overlying landowners do not include the right to transfer groundwater, but that groundwater transfers may be legislatively authorized. Nebraska groundwater statutes specifically authorize interstate groundwater transfers for any purpose, and instate groundwater transfers for public water supply and industrial purposes. Groundwater transfers for agricultural purposes have not been specifically authorized by statute, but transfer authorities may be inferred from natural resources district, reclamation district, and surface wter appropriation statutes.

A. COMMON LAW.

In the first important groundwater allocation decision, *Olson v. City of Wahoo*, the Nebraska Supreme Court stated that a landowner could use groundwater for a "reasonal and beneficial use upon the land which he owns", suggesting that groundwater could be transferred among tracts of land within a single ownership. 124 Neb. 802, 811, 248 N.W. 304, 308 (1933). *Olson* did not deal with the transfer issue, however, and the Court probably meant that groundwater could be used only on a tract of land where the water was withdrawn. In a more recent decision, however, the Court apparently adopted that American rule distinction of overlying land and non-overlying land, rather than the *Olson* distinction of owned land. *State v. Sporhase*, 208 Neb. 703 (1981). Whether the court meant anything different from this distinction is unclear. In American rule jurisdictions, however, overlying land means the land from which the groundwater was withdrawn, not any land overlying the groundwater supply. If the latter interpretation were adopted, the overlying land concept would be similar to the river basin concept of surface water law: all land overlying a common groundwater supply would be considered overlying land and groundwater transfers would be allowed if both tracts were overlying the same aquifer. Whether the Court intended this broader interpretation or the more limited, traditional interpretation of what constitutes overlying land is unresolved. In *Sporhase* and in *Metropolitan Utilities Dist. v. Merritt Beach Co.*, however, the Court stated that groundwater transfers were permissible if they had been legislatively authorized. 179 Neb. 783, 140 N.W.2d 626 (1966).

B. STATUTES.

Nebraska groundwater statutes specifically authorize interstate groundwater transfers for any purpose, and instate groundwater transfers for public water supply and industrial purposes. Groundwater transfers for agricultural purposes have not been specifically authorized by statute, but transfer authorities may be inferred from natural resources district (NRD), reclamation district, and surface water appropriation statutes.

1. Public water supply groundwater transfers.

Public water suppliers are authorized to obtain a Department of Water Resources (DWR) permit to transfer and recharge groundwater. Neb. Rev. Stat. secs. 46-638(1), -645. Public water suppliers are defined as a city, village, municipal corporation, metropolitan utilities district, rural water district, NRD, irrigation district, reclamation district, or sanitary improvement district supplying or intending to supply water to urban or rural areas for domestic or municipal purposes. **Id.** sec. 46-638(2). A permit may be granted, after notice and hearing, if the DWR director finds that the withdrawal and transportation of groundwater is reasonable, is not contrary to the conservation and beneficial use of groundwater, and is otherwise not detrimental to the public welfare. **Id.** sec. 46-642. The

same procedure is followed for public water suppliers to appropriate water for groundwater recharge. **Id.** sec. 46-645. Landowners damaged by the public water supplier's groundwater withdrawals may sue for damages. **Id.** 46-647. The act's validity was sustained in the *MUD* case, **supra**.

2. Industrial groundwater transfers.

Groundwater transfers or withdrawals involving at least 3000 acre feet of groundwater annually require a DWR permit. Neb. Rev. Stat. sec. 46-677. The permit may be granted, after a public hearing, if the DWR director finds that the proposed transfer or withdrawal are in the public interest. In making the public interest determination the director must consider: (1) possible adverse effects on existing surface and groundwater uses; (2) possible adverse effects regarding reasonably forseeable future water needs for domestic and agricultural purposes; (3) alternative water supplies available to the applicant; (4) the economic benefit of the proposed use; (5) the social and economic benefits of existing water uses, and (6) whether the applicant has obtained any waivers of liability from local landowners or water users. **Id.** Land owners of water rights holders damaged by the industrial groundwater withdrawals may sue for damages. **Id.** sec. 46-686.

3. Interstate groundwater transfers.

A DWR permit is required before groundwater in Nebraska can be transported to another state. Neb. Rev. Stat. sec. 46-613.01. The permit can be issued if the DWR director determines that the proposed use is reasonable, is not contrary to the conservation and use of groundwater, and is not otherwise detrimental to the public welfare. A reciprocity clause was invalidated by the U.S. Supreme Court. *Sporhase v. Nebraska*, 50 U.S.L.W. 5116 (1982) reversing in part *Nebraska v. Sporhase,* **supra.**

4. NRD and reclamation district implied groundwater transfer authority.

NRDs and reclamation districts are authorized to "develop, store and **transport** water" for any and all beneficial purposes, including irrigation. Neb. Rev. State. secs. 2-3238, 46-541(9) (emphasis added). This language is very broad, and may include the authority to transport groundwater. This authority has not been judicially interpreted, however.

5. Appropriation groundwater transfer authority.

Individuals are authorized to use a stream or stream channel as a means for transporting "water" from one point to another if written approval has been obtained from a majority of the affected landowners. Neb. Rev. Stat. sec. 46-252. The DWR determines how much of the water transported has been lost in transit, and how much may be withdrawn downstream. Water transported pursuant to sec. 46-252 is not subject to appropriation if the above procedures have been followed. The person conveying the water is liable for any damages caused. The statute is not limited to surface water but refers to "water" generally. The statute probably was intended to apply to groundwater and has been so interpreted by the DWR.

C. EVALUATION.

Nebraska statutes explicitly authorize groundwater transfers for public water supply and industrial purposes if a DWR permit has been obtained. Groundwater transfers authorities for agricultural purposes may be inferred from surface water appropriation statutes and natural resources district statutes, although these authorities are unclear. The absence of a clear legislative authorization to transfer groundwater for agricultural purposes is a major constraint to supplemental water development for irrigation.

1. Public Water Supply Permits.

The major requirement for a public water supply groundwater transfer permit is that the DWR director must find that the proposed withdrawal and transfer of groundwater are "reasonable, not contrary to the conservation and beneficial use of groundwater, and not otherwise detrimental to the public welfare." What constitutes reasonableness in this context is not clear, but it might mean that the amount of water requested is not excessive. What is meant by conservation and beneficial use of groundwater is similarly unclear, although these somewhat vague criteria afford the DWR director broad administrative discretion in making these groundwater allocation decisions. The public welfare criterion for all practical purposes is identical to the public interest criterion discussed above in subsection 1. These criteria taken together were probably intended to have an effect similar to the public interest criterion discussed above, and would have Similar procedural and substantive impacts in constraining groundwater transfers for public water supply purposes. The permit requirement facilitates supplemental water supply development by clarifying the permittee's water rights similar to the appropriation permit procedure described above.

Public water supply permit holders may be sued by neighboring landowners for interfering with the landowner's groundwater rights. While this may be perceived as a constraint to groundwater development for supplemental public water supply purposes, this requirement also facilitates such development by reducing the legal basis for opposing public water supply groundwater uses. The absence of such a "constraint"

could make groundwater development for public water supply purposes politically more difficult to implement.

2. Industrial Groundwater Permits.

The major requirement for industrial groundwater use and transfer permits is that the DWR director may grant the application if the proposed industrial groundwater use would be in the public interest. In making that determination the director must consider the adverse impact of the proposed industrial use on present and future local domestic and agricultural uses, the availability of alternative supplies, the economic and social benefits of local water uses and the proposed industrial use, and whether the applicant has obtained waivers of liability from neighboring landowners. The public interest requirement is similar to the surface water appropriation public interest criterion discussed above, and would have similar procedural and substantive impacts in constraining groundwater transfers for public water supply purposes. The permit requirement facilitates supplemental water supply development by clarifying the permittee's water rights, similar to the appropriation permit procedure described above.

Industrial groundwater use permit holders may be sued by neighboring landowners for interfering with the landowner's groundwater rights. While this may be perceived as a constraint, it also facilitates supplemental water supply development by reducing the legal and political bases for opposing industrial groundwater uses. The absence of such a "constraint" could make groundwater development for industrial purposes politically more difficult to implement.

3. Agricultural groundwater transfers.

Agricultural groundwater transfers are severely constrained by existing law because such transfer authorities are ambiguous at best. Surface water appropriation statutes appear to authorize groundwater transfers for agricultural purposes if the stream channel is used as the means of conveyance. The statutes have been so administered by the DWR. Reclamation district and natural resources district statutes also imply a district right to transfer groundwater for agricultural purposes. These somewhat cryptic authorizations of groundwater statutes stand in stark contrast to Nebraska Supreme Court decisions stating that the legal authority for groundwater transfers in Nebraska are severely limited. This ambiguity could be resolved through legislation clearly authorizing agricultural groundwater transfers. The public water supply and industrial groundwater transfer permit statutes and the interbasin surface water statutes may serve as models for any agricultural groundwater transfer permit statute.

IV. SUMMARY

The three aspects of Nebraska surface and groundwater law most constraining supplemental water supply development are: (1) the preference for junior natural flow appropriators over senior storage appropriators during the irrigation season: (2) the absence of clear statutory authorities to store water underground and to effectively manage water stored underground; and (3) the absence of clear agricultural groundwater transfer authorities.

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APPENDIX E*

by

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**This Appendix was written before the 1983 legislative session and does not reflect any bills passed during that session.*

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APPENDIX E
INSTITUTIONAL ARRANGEMENTS FOR WATER DEVELOPMENT

While water development (i.e. well installation, impoundment development, etc.) occurs within the basic framework of Nebraska water law, federal policies have a profound influence on water development activities, particularly surface water development (i.e. large multipurpose surface water impoundments). The reason is simple: the federal government traditionally has financed surface water project development. In the absence of this federal funding few if any major surface water impoundments would exist in Nebraska. State and local water agency authorities are also significant, as they define how water rights are acquired and how local project sponsors may organize to obtain a federal water resources project. This paper briefly surveys federal, state and local agencies which affect water development in Nebraska, and the legal framework within which these agencies operate.

I. WATER RESOURCES DEVELOPMENT AGENCIES

A. FEDERAL WATER RESOURCES AGENCIES

Many federal agencies have authorities directly and indirectly affecting state water development authorities. Some of these authorities are briefly reviewed here. More thorough reviews of these federal authorities are contained in: Nat'l Water Comm'n, **A Summary-Digest of the Federal Water Laws and Programs** (1973); Neb. Soil & Water Conservation Comm'n, **Survey of Nebraska Water Law** 74-97 (Report on the Framework Study, Appendix D, 1971) and Mo. River Comm'n, **Legal and Institutional Technical Paper** 93-118 (Platte River Basin-Nebraska Level B Study, 1975).

1. U.S. Bureau of Reclamation

The federal reclamation program is administered by the Bureau of Reclamation, U.S. Department of the Interior. The federal reclamation program was established by Congress in the Reclamation Act of 1902. The original purpose of the program was to store and deliver irrigation water to encourage settlers to "reclaim" or, more accurately, claim land in the West for farming under the homestead and other public land laws. Nat'l Water Comm'n, **supra**, at 149. The Bureau's responsibilities now includes furnishing water to irrigate private lands, as well as providing water for recreation, fish and wildlife, flood control, hydropower generation, industrial, and other non-irrigation purposes. 16 U.S.C.A. sec. 505. The reclamation program was initially financed from the sale of public land in the arid West. **Id.** sec. 391. Now Bureau water projects are financed by direct Congressional appropriations. **Id.** sec. 414.

The Bureau is authorized to conduct reconnaissance (i.e. preliminary planning) studies for irrigation projects. **Id.** sec. 411. These studies are financed on an equal basis by Congress and the local project sponsor. Nat'l Water Comm'n, **supra**, at 151. The basic purpose of a reconnaissance study is to determine whether supplemental water is needed and available. These water supply studies have also provided valuable management information even if a reclamation project is not ultimately developed.

If the reconnaissance study is favorable, the Bureau Congress to authorize a more detailed feasibility study. Feasibility studies must be authorized by Congress. 16 U.S.C.A. sec. 4601-19. The feasibility report includes a description of the proposed project, its estimated costs, its cost allocation to specific project water uses, and the expected charges to project beneficiaries. Nat'l Water Comm'n, **supra**, at 151. The project feasibility study must also include a draft environmental impact statement (EIS). 37 F.R. 24910. The draft EIS must include a detailed statement of: (1) the environmental impact of the proposed project, (2) any unavoidable adverse environmental effects of implementing the project, (3) alternatives to the proposed project, (4) the relationship between local short-run uses of man's environment and the maintenance and enhancement of long-term productivity, and (5) any irreversible and irretrievable committments of resources involved in implementing the proposed project. 42 U.S.C.A. sec. 4332(2)(C). The Bureau must also consult with the federal Bureau of Sport Fisheries and Wildlife and the state fish and wildlife agency in the affected state pursuant to the Fish and Wildlife coordinating act. 16 U.S.C.A. sec. 662.

When the comments regarding the feasibility report have been incorporated, the Secretary of Interior forwards the report to the Office of Management and Budget for its comments, which are transmitted with the report to Congress. Nat'l Water Comm'n, **supra**, at 152. While previously reclamation projects could be undertaken with Presidential approval only, current practice is for Congress to specifically authorize all major projects. **Id**.

Repayment by irrigators is limited to construction costs, not interest. **Id**. at 153. For multi-purpose projects, the construction cost of irrigation features are charged to irrigators. 43 U.S.C.A. sec. 462. Irrigators using project water are also required to pay operation and maintenance expenses. **Id**. sec. 492. Payments may be deterred for up to 10 years during the initial operation of the project. **Id**. sec. 485(h).

2. Other Agencies

The U.S. Army Corps of Engineer's water resources functions include the evaluation, design, construction, operation, and maintenance of water projects for navigation, flood control, hydroelectric power generation, municipal and industrial water supply, recreation, and fish and wildlife conservation. Nat'l Water Comm'n, **supra**, at 73. The Environmental Protection agency administers federal water quality protection programs. **Id**. at 98-128. The Soil Conservation Service, U.S. Department of Agriculture, provides financial assistance to landowners for soil and conservation practices. The SCS also prepares watershed conservation plans for soil and water conservation planning. **Id**. at 36-46. The U.S. Geological Survey collects water availability, quality and use data nationally through monitoring streamflow and groundwater levels, and through water quality sampling. **Id**. at 140.

B. STATE WATER RESOURCES AGENCIES

Several state agencies are responsible for programs that may encourage and constrain supplemental water supply development. These agencies, and local agencies with water development authorities, are briefly reviewed here. More detailed explanations of state water resources laws and programs are contained in Neb. Soil & Water Conservation Comm'n, **Survey of Nebraska Water Law** 74-97 (Report on the Framework Study, Appendix D, 1971) and Mo. River Basin Comm'n, **Legal and Institutional Technical Paper** 93-118 (Platte River Basin-Nebraska Level B Study, 1975).

1. Department of Water Resources

The DWR performs the state engineer function in Nebraska, being responsible for granting and administering surface water appropriations. The DWR also has significant groundwater responsibilities regarding well registration, abandonment and spacing. The DWR provides state oversight in administering the Groundwater Management and Protection Act. The DWR administers the groundwater control area well permit program, as well as granting permits for industrial, municipal and interstate groundwater transfers.

The DWR does not have water project financing, construction and operation authorities similar to those of the California Department of Water Resources. The organization of the California Department of Water Resources is somewhat different, reflecting its water development responsibilities. The California State Water Resources Board is responsible for allocating and general administration of surface water appropriations. Cal. Water Code sec. 179. The Department of Water Resources is responsible for administering appropriations through "water master service" and for planning, constructing and operating the State Water Resources Development System. **Id**. secs. 124, 12931. Thus the Department must obtain appropriations from the Board, rather than the Department being responsible both for granting appropriation and constructing projects based on those same appropriations.

2. Natural Resources Commission

The Nebraska Natural Resources Commission has significant authorities related to supplemental water supply development, but does not have project construction or operation authorities. The NRC administers the Nebraska Resources Development Fund, which makes limited state financial support available for water project development. The NRC is authorized to reserve land for water project construction and to purchase storage space in water projects. Neb. Rev. Stat. sec. 2-3267.

The NRC is primarily responsible for state water planning. **Id**. sec. 2-3282. State water planning responsiblities include planning and designing water resources projects. **Id**. sec. 2-3282(4).

3. Other Agencies

The Game and Parks Commission is responsible for administering the Nebraska Endangered Species Act. The GPC also is authorized to purchase wildlife habitat, and to purchase what amounts to conservation easements of private land for habitat purposes. The Department of Environmental Control administers all state water quality programs, except the Health Department's drinking water quality program. The University of Nebraska Conservation and Survey collects groundwater availability, use and quality data, which is used both for development and management decisions.

C. LOCAL WATER DEVELOPMENT AGENCIES

Public and private entities may develop surface water

storage facilities in Nebraska. Several public entities are specifically authorized by Nebraska statutes to develop surface water storage facilities for irrigation, including: reclamation districts, irrigation districts, public power and irrigation districts, and natural resources districts. Any entity, public or private, intending to develop surface water storage facilities must comply with surface water appropriation requirements to appropriate surface water, to construct a storage reservoir, and to use water stored in a reservoir.

1. Reclamation districts.

Reclamation districts may be formed by petition of local landowners to the Nebraska Department of Water Resources (DWR). Neb. Rev. Stat. secs. 46-515 to -522. The district is governed by a locally elected board of directors. **Id.** secs. 46-530 to -541. A district is authorized to supply water for municipal, domestic, irrigation, power, milling, manufacturing, mining, metalurgical, hunting, fishing, recreational development, and other beneficial purposes. **Id.** sec. 46-541(9) & (14).

A district may tax all real estate within the district up to 3.5 cents per $100 actual value (one mill) to pay for district organization, operation, construction and maintenance. **Id.** secs. 46-542 to -543. A district may also levy water service assessments (1) against lands located in municipalities or irrigated districts, and (2) against other lands benefited by water service contracts. **Id.** secs. 46-542, 46-545 to -553. Special benefits of up to seven cents per $100 actual value (two mills) may be assessed against land within a district receiving groundwater recharge benefits but not receiving district water service. **Id.** 46-544. A district may issue bonds (subject to voter approval) and revenue bonds, and may impose deficiency levies if necessary. **Id.** secs. 46-546 to -546.05, 46-553.

2. Irrigation districts.

Irrigation districts may be formed by landowner petition to the local county board for the purposes of providing an irrigation water supply. Neb. Rev. Stat. sec. 46-101 to -107. Land irrigated by pumping ground or surface water cannot be included within a district without the written consent of the owner. **Id.** sec. 46-108. A district is governed by a locally elected board of directors. **Id.** secs. 46-109 to -121. A district may establish water charges or land assessments to pay for district organization, operation and maintenance. **Id.** sec. 46-152. Construction bonds may also be issued if approved in a special election. **Id.** secs. 46-144, 46-193 to 1,127. A district may establish a general assessment against all agricultural land in the district for maintaining existing irrigation works.

3. Public power and irrigation districts.

Public power and irrigation districts (also called public power districts and public irrigation districts) may be formed by landowner petition to the DWR for the purposes, among other things, of providing an irrigation water supply. Neb. Rev. Stat. secs. 70-604, 70-605 to -608, 70-627. A district is governed by a locally elected board of directors. **Id.** secs. 70-609 to -121. A district may establish water charges pursuant to a water service contract. **Id.** secs. 70-630, 70-655. Section 70-677 purports to give a district all the authorities (including financial authorities) of reclamation district.

4. Natural resources districts.

Natural resources districts (NRDs) are multi-purpose political subdivisions established river basin lines with broad and varied natural resources responsibilities. NRDs are governed by a locally elected board of directors. Neb. Rev. Stat. secs. 2-3213 to -3222. NRDs have a general mill levy authority of up to 3.5 cents per $100 actual value (one mill) for general operations, including water project planning. **Id.** sec. 2-3225. The mill levy may be raised if approved by local voters. **Id.** NRDs are authorized to develop water supply projects for any beneficial purpose, and to provide water service for domestic, irrigation, milling, manufacturing, mining, metalurgical, and any other beneficial purpose. **Id.** secs. 2-3229 (5), 2-3238. NRDs are authorized to supply water to rural areas for rural domestic and livestock watering purposes. **Id.** sec. 2-3229. NRDs may contract for irrigation water service and levy assessments against land furnished with irrigation water. **Id.** sec. 2-3239. Irrigation projects (and other water projects) may be financed by special assessment in improvement project areas. **Id.** secs. 2-3252 to -3253. NRDs may issue bonds to finance improvement project areas projects. **Id.** secs. 2-3254.01 to -3254.07. NRDs are also authorized to issue revenue bonds. **Id.** 2-3226.

5. Other local entities.

Primary and second class cities and counties are authorized to develop surface water reservoirs for water supply purposes. Neb. Rev. Stat. secs. 15-244, 17-529, 23-308. They also have more general authorities to initiate water supply projects, as do sanitary improvement districts. See **Legal and Institutional Technical Paper**, **supra**, at 119-27; 132-33. Counties are also authorized to zone rural land uses to protect among other things water supplies. Neb. Rev. Stat. secs. 23-114, -114.03. Sheridan county has adopted a zoning ordinance banning industrial groundwater exports from the county.

D ANALYSIS

Supplemental water supply development functions are allocated between local, state and federal agencies. Historically few real institutional constraints (as opposed to financing constraints) existed to develop a federal supplemental irrigation water supply project (in this con-

text, principally a federal reclamation project). Federal policies have been the most important as they determined whether and how projects would be financed. State and local policies complimented federal reclamation policies in authorizing whatever legal and institutional authorities were necessary to secure federal funding for the water project. The local governmental entity ("local sponsor") was responsible for organizing the local water district (irrigation district, reclamation district, etc.), promoting the project locally and in Congress, and, if the project was completed, performing project operation and maintenance. The state's role was granting the necessary water rights, as well as providing legal authorization for the project sponsor to organize and obtain taxing authority to finance its promotional and other operations. The federal government analyzed project feasibility, financed the project through the reclamation program (as funds were available), and supervised project construction.

Under this system the major requirements for obtaining a project were (1) for the local sponsor to organize the water district, (2) for the necessary water rights to be obtained, and (3) for Congress to finance project construction. The only real constraint in this system was Congressional funding, which depended largely on (1) whether the proposed project could meet federal cost-benefit tests, and (2) whether federal funds were available for the project. In other words, if the local sponsor took the initiative to organize and to obtain the necessary water rights, if the proposed project met the federal financial feasibility tests, and if federal funds were available for project construction, few if any other institutional factors traditionally constrained developing supplemental irrigation water supply projects.

More recently the traditional approach to developing federal supplemental water supply projects has changed in two important ways: environmental considerations now must be more carefully evaluated in project planning, and future federal financial assistance will be contingent upon significant state and local funding. Under these new circumstances, the major constraints to developing supplemental irrigation water supply projects are environmental and financial. These topics are discussed in parts II and III of this appendix.

One difficulty with supplemental water project development is that local sponsors often lack full time professional staff to shepherd a proposed project through the state and federal administrative and political processes. Relying on volunteers (e.g. locally elected reclamation district directors) to serve as local sponsors may limit the local sponsor's effectiveness. This no longer is the case in Nebraska with the advent of NRDs, which have full time professional staff. Developing supplemental water projects might be additionally facilitated, however, if a state agency were granted project planning, development, financing and construction authorities, similar to the California Department of Water Resources. Current state and local institutional arrangements do not constrain supplemental water supply development. Such development might be facilitated, however, by establishing a state supplemental water supply development agency.

II. INSTITUTIONAL CONSTRAINTS: ENVIRONMENTAL

As noted above, the primary constraints to supplemental water development are not organizational in terms of inadequate legal authorities, but rather environmental and financial. This part discusses federal and state environmental laws relating to water development.

A. FEDERAL ENVIRONMENTAL LAWS

While many federal programs encourage water development, other federal statutes require that environmental factors be considered in water development activities, and may even limit water development activities. This section briefly surveys the federal environmental statutes which affect federal water development programs.

1. Fish and Wildlife Coordinating Act

The first federal statute addressing the possible conflict between water development and environmental preservation is the 1934 Fish and Wildlife Coordination Act, 16 U.S.C.A. secs. 661 to 666c. The act requires consultation with state and federal fish and wildlife officials before federal water diversion or impoundment projects are implemented. **Id.** sec. 662(a). Land may be acquired to mitigate any loss of wildlife habitat associated with the federal water project. **Id.** sec. 663(c).

2. Wilderness Act

The Wilderness Act of 1964 created a system for preserving federal lands having wilderness characteristics. 16 U.S.C.A. secs. 1131 to 1136. Under the Act water resources projects can be established in designated wilderness areas only with Presidential approval if the President determines that the national interest would be better served with the water development than without it. Id. sec. 1132(d). A small portion of the Gila Wilderness in New Mexico was innundated as part of the Colorado River Project. Reitze, **Environmental Planning** at 7-32 (1974). No wilderness areas have been designated in Nebraska.

3. Wild and Scenic Rivers Act

The 1968 Wild and Scenic Rivers Act provides for regulation of land uses, including water project development, in river corridors for wild, scenic or recreations rivers included in the wild and scenic rivers system. 16

U.S.C.A. secs. 1271 to 1287. Rivers may be designated as wild, scenic or recreational by Congress, by or pursuant to a state statute, or by the Secretary of the Interior upon a Governor's petition. **Id.** sec. 1273(a). Federal agencies may not construct, finance, license or otherwise assist in developing a water project on an included river if the proposed development would interfere with the river's designated status. **Id.** 1278(a). Similarly, federal assistance or approval may not be given to rivers being evaluated for designation in the wild or scenic river system. **Id.** sec. 1278(b). [Interestingly, Congress disclaims an intent to reserve more water than is necessary to fulfill the purposes of the designation in designating a stream as wild, scenic or recreational. **Id.** 1 284(c). This suggests that Congress does intend to reserve as much water as is necessary to fulfill the purposes of the designation. However, another provision disclaims any intent to interfere with existing water rights, suggesting that the water reservation is not retroactive. **Id.** sec. 1284(f). No wild and scenic rivers have been designated in Nebraska; nor are any rivers being evaluated for possible designation.

4. National Environmental Policy Act

The 1970 National Environmental Policy Act requires all federal agencies to prepare an environmental impact statement (EIS) regarding "major federal actions significantly affecting the quality of the human environment." 42 U.S.C.A. secs. 4321 to 4370; 4332(2)(C). The EIS must include a detailed statement of: (1) the environmental impact of the proposed project, (2) any unavoidable adverse environmental effects of implementing the project, (3) alternatives to the proposed project, (4) the relationship between local short-run uses of man's environment and the maintenance and enhancement of long-term productivity, and (5) any irreversible and irretrievable commitments of resources involved in implementing the proposed project. **Id.** Two surface water projects affecting Nebraska have been delayed through litigation regarding the adequacy of a final EIS: the Gray Rocks power project on the North Platte river near Wheatland Wyoming, and the Bureau's proposed Norden irrigation project on the Niobrara river in north-central Nebraska. *Nebraska v. Rural Elec. Adm'n* 12 E.R.C. 1157 (D. Neb. 1978); *Save the Niobrara Ass'n v. Andrus*, 10 E.R.C. 1665 (D. Neb. 1977).

5. Endangered Species Act

The 1973 Endangered Species Preservation Act requires federal officials to take all steps "necessary to insure that actions authorized, funded, or carried out by them do not jeopardize the continued existence of endangered species and threatened species [so identified by the Secretary of the Interior] or result in the destruction or modification of habitat of such species which is determined by the Secretary, after consultation as appropriate with the affected states, to be critical." 16 U.S.C.A. sec. 1536. This prohibitation normally would apply to regulatory acts (such as the Corps of Engineers sec. 404 dredge and fill permits) as well as Bureau water development activities. However, under limited circumstances federal action may be taken even if endangered species or their habitat are harmed, if the benefits of the federal action outweigh the harm to endangered or threatened species or the habitat.

Regarding critical habitat designation, the U.S. Fish and Wildlife Service has designated critical habitat in the central Platte river area of Nebraska. 50 C.F.R. 17.11 (1980). This means that any federal funding or administrative approval of water projects affecting the central Platte critical whooping crane habitat would require federal endangered species review.

B. STATE ENVIRONMENTAL LAWS

The state environmental statute most likely to inhibit development of supplemental water supplies, particularly surface water development, is the Nebraska Endangered Species Act. Neb. Rev. Stat. secs. 37-430 to -438. The Act requires all state agencies to consult with the Nebraska Game and Parks Commission to determine whether any proposed state activity will interfere with either (1) the contintued existence of a wildlife species designated by state or federal wildlife officials as being threatened or endangered or (2) the species' habitat, determined by the GPC to be critical. **Id.** secs. 37-435(3); -431 (4)(5) (11). The Act also prohibits state agencies from taking action jeopardizing the continued existence of threatened or endangered species or destroying their habitat. **Id.** sec. 37-435(3).

The Act applies to interbasin surface water appropriation applications. *Little Blue NRD v. Lower Platte North NRD*, 210 Neb. 862, 317 N.W.2d 726 (1982). By implication this requirement applies to all state administrative actions relating to water development, including e.g. surface water appropriation applications and development fund applications. In particular, this is likely to apply in the central Platte river area, where several competing irrigation appropriations have been filed, and where the U.S. Fish and Wildlife Service has designated critical whooping crane habitat. 50 C.F.R. sec. 17.11 (1980). Federally designated criticl habitat does not qualify as critical habitat under the endangered species statute, however, unless that habitat is also designated as critical by the Game and Parks Commission.

C. ANALYSIS

1. Federal environmental laws

For the past decade the major federal environmental constraint to developing federal supplemental water

supply projects has been the NEPA requirement that EIS's be prepared for every major federal action significantly affecting the quality of the human environment. NEPA does not require federal agencies to minimize environmental disruption in their activities, so NEPA does not forbid construction of environmentally disruptive water projects. NEPA simply requires that an accurate environmental assessment be prepared. However, federal agencies have often attempted to minimize the environmental consequences of their proposed actions in the EIS. In these circumstances, EIS's have been challanged in court by project opponents, and in some cases have been determined to be legally inadequate. If the EIS is inadequate, it must be revised until the court is satisfied with its adequacy.

Where federal agencies have attempted to minimize the adverse environmental impacts of proposed projects in the project EIS, court challanges often have provided an effective mechanism for project opponents to delay project implementation. While the EIS process can be an opportunity to identify and evaluate ways to minimize environmental disruption from a project, it can also be used by opponents as a way to stop or delay the project. The Nordon/O'Neil unit is an example of a Nebraska reclamation project which has been delayed through NEPA litigation. Other federal laws, such as the Endangered Species Act and the Wild and Scenic Rivers Act, may have similar effects.

A second federal environmental law may constrain supplemental water development in Nebraska. The federal Endangered Species Act requires federal officials to take all steps necessary to insure that federal actions (1) do not jeopardize the continued existence of federally identified threatened or endangered wildlife species or (2) do not modify or destroy such species' habitat federally identified as critical habitat. These requirements apply to federal supplemental water supply development programs. The U.S. Department of Interior has identified critical habitat for the endangered whooping crane in the central Platte river area, which may significantly constrain supplemental water project development using or affecting central Platte river water. The critical habitat designation may also provide a significant measure of protection to that habitat and the wildlife species the habitat supports.

2. State environmental laws

The state environmental law most likely to affect supplemental water project development is the Nebraska Endangered Species Act. The Act requires state agencies to consult with the Nebraska Game and Parks Commission to determine whether any proposed state activity (1) will jeopardize the continued existence of a wildlife species designated by state or federal officials as being threatened or endangered, or (2) will jeopardize the species' habitat determined by the Commission to be critical. The Act also prohibits state agencies from taking action jeopardizing the continued existence of threatened or endangered species or destroying their Commission-identified critical habitat. The Act has been interpreted by the Nebraska Supreme Court as applying both the water rights granting procedures of the Nebraska Department of Water Resources and to the water development activities of local project sponsors. The Act could significantly constrain supplemental water supply development if projects are not developed because they would jeopardize the continued existence of threatened or endangered species or their critical habitat. The Act may also significantly protect threatened or endangered wildlife species.

III. INSTITUTIONAL CONSTRAINTS: FINANCIAL

General federal water development financing programs are briefly discussed relative to federal construction agencies at I(A). Financial authorities of local water development agencies are discussed relative to each agency at I(C). This section deals with state water resources development financing programs.

A. RESOURCES DEVELOPMENT FUND

The Nebraska Natural Resources Commission (NRC) is authorized to provide grants and loans (when the project or program generates revenue) from the Nebraska Resources Development Fund to projects or programs undertaken by state agencies or political subdivisions to promote, among other things, flood control irrigation, outdoor recreation, and soil and water conservation. Neb. Rev. Stat. secs. 2-3263, -3266. Development Fund project or program proposals are evaluated by an advisory board to determine: (1) whether the proposal is economically and financially feasible, (2) whether the proposal is technically feasible (i.e. engineering feasibility), (3) whether the proposal is environmentally acceptable, (4) whether the applicant is qualified to implement the proposal, (5) whether any requested loan can be repaid and whether adequate operation and maintenance will be provided during the loan's term, (6) whether the project is coordinated with other state programs, and (7) whether the necessary funds are available from the Development Fund. **Id.** secs. 2-3270, -3271. Proposals may be approved by the NRC after evaluating the advisory board recommendatons. **Id.** sec. 2-3272.

State appropriations to the development fund have not been sufficient to meet new federal funding requirements to finance major surface water project development.

B. OTHER STATE STATUTES

The NRC is authorized to make grants to NRDs from the Soil and Water Conservation Fund to provide finan-

cial assistance to landowners to establish land conservation practices to, among other things, increase groundwater recharge. Neb. Rev. Stat. secs. 2-1575 to -1582. The Game and Parks Commission is authorized to acquire wildlife habitat through voluntary purchase, lease, or easements. **Id**. sec. 37-216.08.

C. ANALYSIS

Traditionally, as noted above at I(D), the only real constraints to federal supplemental water project development were whether the proposed project met federal financial feasibility criteria, and whether federal funds were available for project construction. If a project qualified for federal funding, (and if federal funds were available) no state funds and only limited local funds were required. This, however, appears to be changing. While new federal financing policies are not yet clearly established (including federal financial feasibility tests), states (including local project beneficiaries) probably will be required to finance between one-quarter and one-third of the project costs to qualify for federal project funding. This means that unless significant state and/or local water development funding sources are developed, the likelihood of constructing additional large federal surface water projects in Nebraska is remote (unless federal funding policies change).

While existing state water development programs are designed to complement the traditional federal supplemental water supply development programs, local sponsors probably have adequate legal authorities to qualify for federal financial assistance even under the changing federal program requirements. (A discussion of federal programs assisting municipal water supply development is contained in the municipal water needs policy issue report.) Natural resources districts, reclamation districts and irrigation districts are currently authorized to levy property taxes, enter into water sales contracts, and to issue bonds to finance water project development. Using existing authorities additional funds could be obtained (1) by requiring water users to pay a greater share of project costs by increasing water use fees, or (2) by levying a higher property tax in the project area.

While existing financing authorities of local project sponsors probably are adequate to qualify for federal financing, political constraints may prevent those authorities from being fully exercised. Existing authorities may not generate the needed funding to qualify for federal financial assistance (1) if local water users are politically unwilling or financially unable to pay high enough water use fees, (2) if local taxpayers are politically unwilling or financially unable to pay high enough taxes to qualify for federal assistance, or (3) both. In such cases, new water development funds could be obtained (1) by increasing the costs to other project beneficiaries (e.g. charging for flood control benefits, recreational uses, etc.), (2) through expanding the Resources Development Fund through a state-wide water use fee, (3) by increased state appropriations for water development, (4) through state-issued revenue bonds or general obligation bonds, or (5) through some combination thereof.

An additional issue is raised if the state provides substantial financial assistance for supplemental water supply projects. As currently administered by the Nebraska Natural Resources Commission, proposed projects must have a positive financial return in order to qualify for Development Fund funding. One problem in evaluating the costs and benefits of proposed water resources projects is the inability to accurately evaluate the indirect regional economic benefits from such projects. This makes it difficult to determine whether a proposed project will have a positive financial return. The state financial feasibility test does restrict supplemental water supply development by preventing development of financially infeasible projects. On the other hand, such a policy establishes the public funds will be spent for projects having a net economic benefits (assuming realistic appraisal of indirect project economic benefits).

IV. SUMMARY

The major institutional constraints to supplemental water project development are environmental and financial. The major federal environmental constraints are the EIS requirement and the central Platte whooping crane critical habitat designation, although both constraints serve environmental protecton concerns. The major state environmental constraint is the requirement that state actions not jeopardize the continued existence of threatened or endangered wildlife species or their critical habitat. The major financial constraints are (1) availability of federal water resources development funds and (2) conditioning availability of federal funds on significant state and local funding. While the latter factor will increase the cost to Nebraskans of federal supplemental water projects, the change in federal financing policies is not necessarily constraining. However, the required state and local financing could come either from higher water use charges, higher local and/or state taxes, or some combination thereof. These changes may prove to be financially, and therefore politically, constraining.

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APPENDIX F
RELATIONSHIP OF THIS POLICY STUDY TO OTHERS

No matter how determined the effort, it is impossible to separate water policy issues into ten, twenty, or fifty separate and distinct issues for policy purposes. Water policy is complex, with many overlaps in issues when any system of categorization is used. In designing the original Policy Issue Studies for the State Water Planning and Review Process in 1978, an attempt was made to separate issues in as logical a fashion as possible. Still, numerous problems are encountered because of this separation.

It is important that the relationships between policy issues be identified. Such identification promotes awareness of the fact that any particular water policy action will have greater impact upon overall water policy than just the resolution of the immediate issue at hand.

Based upon the information available at the time of this writing, significant relationships can be identified between *Supplemental Water Supplies* and most other policy issue studies. A discussion of these relationships for each of the other studies follows.

STUDY #1: INSTREAM FLOWS

The *Instream Flows Policy Issue Study* final report was published in January 1982. The report contains a policy alternative which allows instream flow needs to be met through the use of stored water and another alternative which prohibits the use of stored water. Another alternative in the report provides for supplementing natural flow needs through groundwater.

There is little doubt that the streamflow characteristics of some streams have been dramatically altered by the development of supplemental water supply systems in the state. Supplemental facilities themselves often stabilize or change the timing of streamflows while the uses of that supplemental flow can cause various levels of depletion downstream. In some cases this has caused lower off-season flows in order to fill a storage facility combined with low peak season flows as a result of irrigation use. However, in other cases the stabilized flow levels have improved instream values. In a number of cases, instream values are improved instream values are improved in segments where water is to be delivered to downstream users. Supplemental projects can be built with instream values specifically in mind. In some streams storage rights for instream flows would have to be obtained. Although Nebraska law does not explicitly authorize the use of stored waters, the Department of Water Resources has interpreted state statutes to allow the issuance of storage use permits for this purpose. However, no public or private entity has yet tried to obtain a storage use permit for the purpose of maintaining instream flows. Those readers interested in more information on this issue should refer to the *Policy Issue Study on Instream Flows*.

STUDY #2: WATER QUALITY

There are a number of impacts supplemental water projects can have on water quality. A range of environmental constraints and impacts, including water quality, are presented in Chapter 4 of the *Supplemental Water Supplies Report*. Although the *Policy Issue Study on Water Quality* contains a number of alternatives on nineteen different problems, none of these problems is related directly and specifically to supplemental facilities. However, a number have applicability to supplemental projects and uses.

STUDY #3: GROUNDWATER RESERVOIR MANAGEMENT

The *Policy Issue Study on Groundwater Reservoir Management* and the *Policy Issue Study on Supplemental Water Supplies* are closely related in some respects. Because groundwater aquifers can serve as storage mechanisms, many of the maps presented in the *Groundwater Reservoir Management Study* are pertinent to this study and, in some cases, they are used in both studies. Other physical information pertinent to groundwater storage is contained in the text of the *Groundwater Reservoir Management Report*.

STUDY #4: WATER USE EFFICIENCY

Achieving greater water use efficiency is often thought of as one source or method of supplementing water supplies. Because a separate study is being conducted on water use efficiency policy the *Supplemental Water Supplies Study* did not consider as supplemental water natural streamflow diverted to riparian land or groundwater used within one mile of the point of withdrawal. Neither did it consider specific use practices. It is recognized that conservation of water through more efficient use is an alternative way to make up for a shortage of water.

The task force for the *Policy Issue Study on Water Use Efficiency* is due to submit its final report in June of 1984. In combination with this study, that report will provide ways of more thoroughly utilizing our water supply.

STUDY #5: SELECTED WATER RIGHTS ISSUES

The *Selected Water Rights Issues Policy Study* produced seven separate reports with varying degrees of relation to the *Supplemental Water Supplies Study*.

The *Water Use Preference* report contains a number of alternatives which could affect water augmentation plans. In some cases, surface water preferences might limit the amount of water which could be taken from a stream for recharge purposes. In other cases, the same preferences could help justify supplementing natural streamflows with available groundwater.

The relationship to groundwater preferences will be even more direct, especially if those preferences are confirmed to be and remain absolute in nature. If augmentation of surface supplies would conflict with any preferred groundwater use every one included later in time, the augmentation would have to be discontinued or damages paid the preferred user.

The *Drainage of Surface Water Report* contains a number of alternatives which affect a landowners right to capture and use diffused surface water. There would be an impact, however the structures affected would all be well below the project size anticipated in the *Supplemental Water Supplies Report*. Indeed, to the extent that the water was made unavailable for project scale uses elsewhere, supplemental projects could find smaller than anticipated water supplies.

The *Water Rights Adjudication* report has only a minor relation to the *Supplemental Water Supplies Study*. This derives from the relation between using surface water for groundwater recharge and the modification that may require in appropriation permits. Similarly the *Property Rights in Groundwater* report has a minor relation to the *Supplemental Water Supplies Study* in that the practicability of recharge schemes and the extent of groundwater use could be affected by alternatives in the Report.

Some alternatives in the *Riparian Rights* report could decrease the amount of water available for storage or delivery to areas with inadequate supplies. This would occur through recognition and administration of additional claims to surface water supplies.

The *Interstate Water Uses and Conflicts* report is very pertinent to the *Supplemental Water Supplies Study* on a number of points. In general, one of the best ways to build a favorable position for purposes of interstate allocations is to make beneficial use of as much water as possible. The *Supplemental Water Supplies Study* includes numerous alternatives which would result in more complete use of water. *Alternative #32* (Direct some entity to develop a plan to obtain and use supplemental water from the Missouri River) is especially pertinent to the *Interstate Water Uses and Conflicts Report*.

Three alternatives in the *Interstate Water Uses and Conflicts Reports* are particularly related to supplemental supplies. These are *Alternative #8* (Additional water project financing), *Alternative #9* (Authorize purchase of water rights in other states), and *Alternative #10* (Authorize State participation in project construction in other states).

The *Transferability of Surface Water Rights* report has a minor relation to supplemental supplies in that voluntary transfers of water rights are one method that could be used to supplement water supplies in any particular location.

STUDY #6: MUNICIPAL WATER NEEDS

Because municipal use potentially may require supplemental supplies there is a significant relationship between the *Municipal Water Needs* and *Supplemental Water Supplies Reports*. Chapter 2 of this report contains a discussion of potential municipal needs. Chapter 4 of the *Municipal Water Needs Report* discusses municipal sources. *Alternative #13* in the *Municipal Water Needs Report* (establish a State fund to provide relief for municipal systems needing improvement) has potential for helping municipal systems provide supplemental supplies.

STUDY #8: INTERBASIN TRANSFERS

STUDY #9: WEATHER MODIFICATION

These two studies are no longer scheduled for completion as part of the State Water Planning and Review Process. Therefore, no attempt has been made to identify possible relationships with this study.

STUDY #10: WATER-ENERGY

Because supplemental facilities are often multipurpose, they can be used for hydropower purposes. They also can be used to provide supplemental water for other types of energy generating facilities. Although the *Water-Energy Policy Study* has not yet been completed it will contain information on potential areas of future energy demand for water. Supplemental facilities could be required for some of these areas.

STUDY #11: INTEGRATED MANAGEMENT OF SURFACE WATER AND GROUNDWATER

Although work on the *Policy Issue Study on Integrated Management of Surface Water and Groundwater* has just begun it is possible to say that it will have a major relationship to the *Supplemental Water Supplies Report*. Sections related to integrated management and groundwater recharge in this study will be especially pertinent to the *Integrated Management of Surface Water and Groundwater Report*. However, in addition to examining surface water's effects on groundwater the contributions of groundwater to surface water will be a major focal point in that study.

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APPENDIX G
SUMMARIES OF PUBLIC MEETINGS, POLICY ISSUE STUDY ON SUPPLEMENTAL WATER SUPPLIES: OGALLALA, GRAND ISLAND AND NORFOLK, NEBRASKA

SUMMARY OF PUBLIC MEETING
POLICY ISSUE STUDY ON SUPPLEMENTAL WATER SUPPLIES

8:00 p.m.
May 31, 1983
Ogallala, Nebraska
Ogallala Holiday Inn

PERSONS ATTENDING

Karen Stansbury, North Platte Telegraph
Shirley Parks, Ogallala, W.I.F.E.
Greg Wingfield, North Platte, Game and Parks Commission
Ronald Milner, Imperial, Upper Republican NRD
Roy Dean Parker, Benkelman, Upper Republican NRD
Marvin Large, Wauneta, Upper Republican NRD
Dan Dudden, Venango, Upper Republican NRD
John Love, Ogallala, Keith County News
Gary Waugh, North Platte, Platte Valley Irrigation
Jim Eshlemer, Hershey, Platte Valley Irrigation
Phil Hort, Lyman, Gering and Ft. Laramie Irrigation
Don Winchell, Gering, Gering and Ft. Laramie Irrigation
Calvin Ewing, Mitchell, Gering and Ft. Laramie Irrigation
Jack Thompson, Sutherland, K and L Irrigation District
Mervyn Gompert, Mitchell, North Platte NRD
Brian Lind, Gering, North Platte NRD
Allen Peterson, Lewellen, North Platte NRD
Kent Miller, North Platte, Twin Platte NRD
James Goeke, North Platte, Conservation and Survey Division, UNL
Bob Kuzelka, Lincoln, Conservation and Survey Division, UNL
Steve Gaul, Lincoln, Natural Resources Commission Staff

PROCEDURE

Commission member Bob Gifford presided over the meeting. Steve Gaul of the Commission staff explained the relationship of the report to Nebraska's water planning process and how comments from the public meetings would be used. Conservation and Survey Division staff member Bob Kuzelka then presented a report summary. An informal discussion and question and answer session was then conducted.

TESTIMONY OFFERED

Mervyn Gompert, Chairman of the North Platte NRD gave a brief oral statement. He felt it was very important to look at river basins as a whole, and not piecemeal. He said that the state should develop ways to use Platte water in higher elevations to the west as much as possible. He also felt the water should be used repeatedly as it crosses the state. He suggested that the benefits of small dams not be forgotten. He said that small dams can provide as many or more benefits than large dams. Mr. Gompert also stated that water resources development should take into account the economics of agriculture. He said that Nebraska should contact Colorado and Wyoming in regard to capturing more water in times of surplus flow.

A discussion and question and answer session then began. One person said that he agreed Nebraska needed to contact Colorado and Wyoming but he felt that to date, Nebraska had talked considerably without building projects. Another person mentioned that without funding it doesn't matter if we have an advocacy agency or other administrative measures.

Kent Miller then suggested that an alternative to modify the State Threatened and Endangered Species Act be added. He felt that economic benefits of projects should also be considered. On another subject, he noted that there never had been enough money in the Natural Resources Development Fund to budget high levels of project development. He asked whether the study task force had considered private investment in supplemental water. He felt that it may be a possibility to get investors who now put money into groundwater development to invest in supplemental water instead.

One person noted that all of the local government funding options appeared to fall back on the local property tax. Another person suggested a lottery as a possible funding mechanism.

It was suggested by one party that *Alternative #7* would need to be considered carefully before using water for that purpose. He felt there might be problems pumping water out of an aquifer, where there is no evaporation or loss, into a stream where such losses may occur.

A comment was made on *Alternative #8* that there are people below dams now who don't believe enough water is being released. It was also noted that water on the Platte is currently used six times as it flows downstream. It was suggested that the Platte is already overappropriated and that junior appropriators will lose no matter what alternative is adopted.

One person stated his concerns about contamination by agricultural chemicals when integrated use is allowed. A comment was also made on the possibility of using revenues from the sale of power from McConaughy to finance water projects.

SUMMARY OF PUBLIC MEETING
POLICY ISSUE STUDY ON
SUPPLEMENTAL WATER SUPPLIES

8:00 p.m.
June 1, 1983
Grand Island, Nebraska
Conestoga Mall, Civic Room

PERSONS ATTENDING

Dale Soffley, Hastings
Senator Howard Peterson, Grand Island
Doyle Hulme, Cairo
Ted Regier, Aurora
Vance Anderson, Hastings, PAB
Michael Shaughnessy, St. Paul, NRC
Norman Obermier, Waco
Jim Henrickson, Grand Island, U.S. Fish and Wildlife
Keith Davis, St. Paul, Loup Basin Reclamation District
Bruce Weible, Grand Island, Grand Island Independent
Bob Lowry, Cairo, PAB
Ron Bishop, Central Platte NRD
Bill Umberger, Tri-Basin NRD and Gosper County
Don McCabe, Lincoln, Nebraska Farmer

Glen Bowles, Kearney, South Central Nebraska Development District
Richard Slama, Lincoln
Robert Kuzelka, Lincoln, Conservation and Survey Division
Steve Gaul, Lincoln, NRC Staff

PROCEDURE

Commission member Jim Cook presided over the meeting. Steve Gaul of the Commission staff explained the relation of the report to Nebraska's water planning process and how comments from the meeting would be used. Conservation and Survey Division staff member Bob Kuzelka then presented a report summary. An informal discussion and question and answer session was then conducted.

TESTIMONY OFFERED

Only one written statement was offered at the meeting. That testimony was presented by **Doyle Hulme** on behalf of the Nebraska Water Resources Association. The written testimony was the same as that offered on behalf of NWRA at the Norfolk public hearing. A summary of that testimony is available by referring to the adjoining section on that public hearing. A written copy of the statement is available at the Natural Resources Commission offices.

Initial comments from the audience concerned the suitability of aquifers mapped in the report to store water. One person questioned whether water could be stored without seeping into adjacent areas. Vance Anderson suggested that Kearney and Phelps county had formations which had been filled with water and that now the drawdown in the Blue Basins could be filled. One person noted that the water table slopes downward and that if there was more irrigation in a lower part of the Platte the Upper Big Blue would be recharged. Another person stated that the state needs to be most concerned with recharging areas where it already has a decline rather than recharging areas that are currently unused. Vance Anderson said that many studies had been done but that the state needed to start doing something. He felt that at some point someone needed to say "this project is #1 and this project is #2" and go down the line.

Richard Slama said that the state should consider economics, which means looking at the value of corn. He felt that the state should look 50-100 years into the future when planning projects. He said that scientists had now discovered perennial corn and that people had little idea of how that would impact the state in the future. Slama also suggested that the true value of water be considered. He stated that the coal slurry pipeline might be part of the answer and that the state could solve financing problems by charging for that type of use of water.

Norman Obermier suggested that with the current economic situation nobody could afford to buy water. He said that he had talked to an exchange student from Argentina who suggested they could raise corn for $1 a bushel and make a profit. He said the U.S. may price itself out of the market if what is needed to grow corn becomes too expensive. He said that many people had started planting beans and stopped pumping even before PIK. However, he felt that small dams were useful for recharge and other purposes.

Ted Regier asked why Nebraska didn't have more hydropower. He noted that he was in China a year ago and that everywhere water falls they generate electricity. He questioned whether our public power system discouraged competition.

Senator Peterson said that he saw a possibility in selling water to a coal slurry pipeline and using the money for water development. He also felt a surcharge on coal trains coming through Nebraska is a possibility. One person stated that soil erosion and plowed up land has resulted in faster runoff and thus more water leaving the state.

Vance Anderson said he felt that it wasn't true that we can't get money from the federal government for water projects. He pointed to an article in the National Water Resources Association newsletter which shows that the Army Corps of Engineers developed 13 new water project proposals for initiation of construction in FY 83 and 84. He said that funds have been provided in the budget for those projects. However, he said that Nebraska won't even support a project where the federal government pays for the whole thing. Another person suggested that local people must do the footwork first.

Richard Slama said that we must change the image of supplemental water projects resulting from things like dam failures. He said that in some irrigated areas irrigation can reduce temperature on hot days by 3 to 5F. He stated that this has a major impact on air conditioning, how many water rights are used, dryland corn yield and on the amount

of moisture corn needs. He suggested that irrigating thus creates supplemental water. He said that irrigated areas pump a great deal of water into the air, which falls as precipitation. He stated that the Great Plains were receiving 14 million extra feet of rain in 1970 versus 1929. Slama stated that Nebraska received 4½ million extra acre-feet of rain. He felt the rainfall chart in the *Supplemental Water Supplies Report* was different from what would have been developed in the 1930's. He concluded that we may have more water in the Platte than what we think because the climate has changed since the 1930's due to the way we farm.

One person then recommended that the state reevaluate the federal whooping crane habitat. He suggested that seven sitings in 50 years shouldn't be stopping water projects in Nebraska.

Bill Umberger urged the Commission to recommend *Alternative #31*, which is the same as LR 6. He said that governments being hurt or inconvenienced by water projects should have compensation.

SUMMARY OF HEARING
POLICY ISSUE STUDY ON SUPPLEMENTAL WATER SUPPLIES

8:00 p.m.
June 2, 1983
Norfolk, Nebraska
Commercial Federal Savings and Loan Building

PERSONS ATTENDING

Dale Lingenfeter, Plainview, LENRD
Ray Vogel, Battle Creek, LENRD
Bert Peters, Lyons, LENRD
Fred Thomas, Omaha, World-Herald
Bob Warrick, Meadow Grove, Sierra Club
Michael Nolan, Norfolk, City of Norfolk
Dr. D. W. Bruster, Norfolk, Norfolk City Council
Steven Oltmans, Norfolk, LENRD
Bruce Trindle, Norfolk, Game and Parks Commission
Elden Wesely, Oakland, LENRD
Dennis Newland, Norfolk, LENRD
DeLynn Hay, Lincoln, Cooperative Extension
Paul Mann, O'Neill, UENRD
Elmer Olberding, Atkinson, UENRD
John Dworak, Atkinson, UENRD
Vincent Kramper, Dakota City, NRC
George Wolverton, Lincoln, League of Nebraska Municipalities
John K. Hansen, Newman Grove, LENRD
Bruce Hanson, Norfolk, Conservation and Survey Division
Clinton VonSeggern, Scribner, NRC
Bob Kuzelka, Lincoln, Conservation and Survey Division
Steve Gaul, Lincoln, NRC Staff

PUBLIC NOTICE

Legal notice of this hearing was published in the Lincoln Journal and Star and the Norfolk Daily News. Press releases were sent to every newspaper, radio, and television station in the state.

HEARING PROCEDURE

Commission chairman Clinton VonSeggern presided over the hearing and Steve Gaul conducted the hearing. Conservation and Survey Division staff member Bob Kuzelka presented a report summary. Those present were then given an opportunity to testify on the report. An informal discussion with questions and answers was then conducted. About 20 people attended the meeting.

TESTIMONY OFFERED

A brief summary of the report noted that it identified and discussed the impacts of alternative legislative and management alternatives which would facilitate the development of supplemental water supplies in Nebraska. Supplemental water was defined as additional water necessary to supply that which is lacking, i.e., needed or desired. The physical maps included in the study were explained and 35 legislative and management alternatives were identified.

TESTIMONY OFFERED

Mr. Steve Oltmans, for Lower Elkhorn Natural Resources District. Mr. Oltmans stated that surface water storage was desirable in the Elkhorn basin to reduce flood damages during high flows and release water for stream augmentation during low flow periods of the year. He then addressed each alternative. In general terms the Lower Elkhorn NRD supported *Alternatives 1, 2, 3, 4, 6, 7, 9, 10, 11, 12, 14, 15, 16, 18, 21, 22, 28, 29, 30,* and *32*. Opposition was expressed to *Alternatives 8, 13, 17, 19, 20, 23, 24, 27, 31, 33,* and *34*. Conditions were placed on the approval of or opposition to a number of alternatives.

Oltmans said that the Lower Elkhorn NRD believed the key results of the Supplemental Water Supplies Study must provide the following: (1) Increased state dollars for constructing water storage projects, (2) An increase in the state's role in planning and providing general leadership for carrying out major storage projects, (3) An increase in dollars for local sponsors of water storage projects, (4) Finally, in Nebraska additional dollars for water storage projects will most likely have to come from a combination of several sources. A written copy of the Lower Elkhorn NRD's statement is available at the Natural Resources Commission offices.

Mr. Steve Oltmans, for Nebraska Water Resources Association. Mr. Oltmans also delivered a statement for the Nebraska Water Resources Association. The same statement had previously been delivered at public meetings in Ogallala and Grand Island.

Mr. Oltmans said that the NWRA had restricted its comments to a comparatively small number of alternatives which it considered to be the most significant. Oltmans noted that the NWRA had strongly supported LB 198 which encompasses *Alternatives 1* through *4*. He also said that NWRA supported *Alternatives 10, 14, 30,* and *32*.

He said that the draft study lacked an alternative regarding environmental constraints and that NWRA supports the idea of amending the Nebraska Endangered Species Act. The NWRA statement suggested that both positive and negative environmental impacts of proposed state projects should be considered. Also suggested was inclusion of a provision which would permit projects to be built even if endangered species or their habitat are harmed, if the benefits of the project outweigh the harm to the endangered or threatened species or their habitat. The statement said that such a provision was included in the federal act.

The statement noted the 272 surface storage sites included in the study and suggested that appropriate agencies initiate action to review the status of any potential facilities and determine those that would provide benefits. The importance of storage underground was stressed in the closing portion of the statement. A written copy of the Nebraska Water Resources Association statement is available at the Natural Resources Commission offices.

Mr. Paul Mann, for Upper Elkhorn Natural Resources District. Mr. Mann stated that he believed LB 198 had addressed *Alternatives 1* through *5*. He said that the Upper Elkhorn feels that putting a value on the recharge of underground water enhances surface water storage prospects by strengthening cost-benefit ratios.

The Upper Elkhorn is installing water control structures on several streams to help stabilize streamflow in summer months. They felt this would be a different approach than *Alternative #7* which the NRD feels could be an expensive program.

The Upper Elkhorn NRD believed that funding is the main deterrent to the development of Supplemental Water Supplies. The NRD stated that Nebraska is well behind some of its neighboring states in setting aside funds for water projects and that the state needed to be more aggressive in approaching funds.

The Upper Elkhorn strongly supported an increase in the state sales tax with that increase being earmarked for the development of water storage projects. However, it recognized some problems with the concept. It was felt that in less populated areas of the state people would have to be taxed at a higher rate for projects than in other areas of the state. There was also some concern that if a special tax was assessed for a project the 7% spending lid would cause difficulties in administering a project.

Mr. Mann said that the Resources Development Fund was underfunded to handle current requests and needed more state emphasis in order to build larger projects. He also noted that the Upper Elkhorn NRD had always shown a great deal of interest in joint use structures.

Mr. Mann stated that the Upper Elkhorn NRD believes there are currently sufficient programs to properly address supplemental water supplies in Nebraska. He said the Natural Resources Commission was a competent agency

to administer those programs if funding was made available to develop them. He closed by saying it was time for Nebraska to become more aggressive and make use of its supplemental water. A written copy of the Upper Elkhorn NRD's statement is available at the Natural Resources Commission offices.

Mr. Bob Warrick, for the Nebraska Chapter of the Sierra Club. Mr. Warrick said that the Sierra Club was acting with concern and mixed emotions on this issue. He said that the Sierra Club recognized agriculture as the heart of the state's economy. However, they felt that demands placed upon water resources by agriculture were many times unreasonable, especially if viewed in the context of the state's first priority being conservation, not providing more water.

The Sierra Club felt that the preparer of the report had done a biased job of defining the problem and its solutions. It felt the draft report was slanted toward development and did not deal adequately with on land conservation of water. The Sierra Club believed that the conservation aspect of the report was dealt with very superficially and deliberately downplayed, especially when it dealt with conservation practices as actually depleting streamflow.

The Sierra Club stated that it believed it was a poor use of taxpayers money to build supplemental water projects, when at the same time the government was spending billions to take acreage out of production because of surpluses. Mr. Warrick said that the Nebraska Sierra Club felt that in the age of state and local budget crisis is is inappropriate to search for ways to fund water projects; projects that had been viewed even by the federal government as a subsidy to agriculture. Warrick said that any projects being considered should be on good fiscal ground and able to repay total project costs. He stated that the cost benefit analysis applied to projects must be realistic, and not of the type used by the Bureau of Reclamation to justify their projects.

Warrick said that the report dealt with environmental constraints as if the Environmental Policy Act, Endangered Species Act, and state environmental laws were enacted by some misguided fringe environmental extremists and not by the Congress of the United States and the Legislature of the State of Nebraska. Warrick said that people support those environmental laws in every national poll that has been taken. He said that projects must stand or fall on being environmentally sound.

Warrick concluded by saying that the age of subsidized water projects was over. He said that agriculture, while important, should not have first call on the state's water sources. A written copy of the Nebraska Chapter of the Sierra Club's statement is available at the Natural Resources Commission offices.

OTHER DISCUSSION

In other discussion **John Hansen** of the Lower Elkhorn NRD said that the lid bill had a significant impact on the building of projects. He said that the NRDs that weren't geared up tax-wise at the time the lid was imposed are now locked into a position where they have trouble even maintaining their existing programs. He felt that the lid should be removed. He stated that if the NRDs were then still incapable of raising a 25% match that consideration could be given to raising taxing capability. He said that safeguards and responsiveness were built in by keeping projects at the local level. He concluded by saying that the state should work toward more efficient use of water. He said that the public would support water if it was being managed efficiently, but that it will not subsidize waste.

Bob Warrick said he had concerns about the groundwater mound in the Tri-County area. He said that the Tri-County System had been using water from Lake McConaughy to build a groundwater mound for 40 years while the Blue Basins needed the water. He felt that it was time for that situation to change.