Report on Hydrologically Connected Ground Water and Surface Water in the Upper Niobrara-White Natural Resources District

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Table of Contents

Table of Figures
Report on Hydrologically Connected Ground Water and Surface Water in the UNWNRD

Appendix I

Appendix II

Report on Hydrologically Connected Ground Water and Surface Water in the Upper Niobrara-White Natural Resources District

Purpose

This report reviews the background information that was used to assist the Department of Natural Resources (DNR) in making its determination of which basins, subbasins or reaches in the Upper Niobrara-White Natural Resources District (UNWNRD) are fully appropriated in accordance with Neb. Rev. Stat. Chapter 46, Article 7. The report describes: 1) the availability of stream flow to meet current surface water rights in the UNWNRD; 2) the hydrologic connection between ground water and these surface water supplies; and 3) how uses of one source of water may affect availability of the other source.

Background

On January 10, 2003, the UNWNRD sent a letter (Figure 1, Appendix I) requesting that the DNR consult with the UNWNRD. The requested consultation concerned studies and a hearing on the preparation of a joint action plan for the integrated management of hydrologically connected ground water and surface water under the Nebraska Ground Water Management and Protection Act.

The DNR responded on February 26, 2003 (Figure 2, Appendix I) with a preliminary decision according to then current law (Neb. Rev. Stat. 46-656.28(2)1998). In that decision the DNR found reason to believe that the use of hydrologically connected ground water and surface water resources in the UNWNRD was contributing to, or was in the reasonably foreseeable future likely to contribute to, conflicts between ground water users and surface water appropriators. The decision was made based on information found in the UNWNRD's ground water management plan, various United States Geological Survey (USGS) reports, various DNR records, and other reports and records. Based upon the preliminary determination, the DNR initiated a more detailed study to determine the cause of such conflicts, disputes, or difficulties and the extent of the area affected.

On July 16, 2004 LB 962 became effective, replacing portions of the Ground water Management and Protection Act pertaining to the integrated management planning process. The new law provided a transition process for natural resources districts that were in the process of determining whether they needed to develop an integrated management plan (Neb. Rev. Stat. 46-720). Under the new law an integrated management plan must be developed if the DNR determines that a basin, subbasin, or reach within the district is fully appropriated (Neb. Rev. Stat. 46-715). This new legislation provides the following standard to determine whether a basin is "fully appropriated":

"A river basin, subbasin, or reach shall be deemed fully appropriated if the department determines that then-current uses of hydrologically connected surface water and ground water in the river basin, subbasin, or reach cause or will in the reasonably foreseeable future cause (a) the surface water supply to be insufficient to sustain over the long term the beneficial or useful purposes for which existing natural flow or storage appropriations were granted and the beneficial or useful purposes for which, at the time of approval, any existing instream appropriation was granted, (b) the streamflow to be insufficient to sustain over the long term the beneficial uses from wells constructed in aquifers dependent on recharge from the river or stream involved, or (c) reduction in the flow of a river or stream sufficient to cause noncompliance by Nebraska with an interstate compact or decree, other formal state contract or agreement, or applicable state or federal laws." (Neb. Rev. Stat. 46-713(3))

Under the provisions DNR must hold a hearing by November 14, 2004 (Neb. Rev. Stat. 46-714 (4)) and make a final determination designating which river basins/reaches in the UNWNRD are fully appropriated within thirty days of the hearing (Neb. Rev. Stat. 46-714 (5)).

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Basic Principles of Ground Water - Surface Water Interactions

1) Where there is a hydrological connection between surface water flow and ground water aquifers, a consumptive use of one depletes the supply in the other.

2) In such areas a decrease in recharge to the aquifer from surface water supplies, precipitation, canal seepage or seepage from irrigated fields, will decrease the amount of water infiltrating from the land surface to recharge the ground water aquifer. A decrease in recharge will also decrease the ground water supplies available for use.

3) Stream flows are supplied by surface water runoff and by water seeping from the ground water aquifer to the stream as baseflow. Surface water runoff tends to be sporadic, depending on precipitation events. Baseflow from ground water is more constant.

4) Changes in baseflow to a stream result from any factor that either changes the water pressure or the water table elevation in any aquifer hydrologically connected to the stream. Consumptive

use of the aquifer by wells or vegetation affects both the aquifer pressure and water table elevation.

5) If a ground water aquifer is closely connected to a surface water stream, decreases in aquifer water pressure or elevation caused by a pumping well will either decrease the movement of water to the stream or induce the movement of water from the stream to the aquifer. In either case, the first noticeable impact of increased consumptive use from an aquifer hydrologically connected to a stream is often a change in the quantity of stream flow rather than a change in the water table elevation of the aquifer. In many cases, changes in water table elevations are detected only when stream flows decline to the point they are no longer able to recharge the aquifer. Thus, in addition to declines in water table elevation, any steady decline in stream flow that cannot be explained by a change in precipitation or other factors is a good indication that the current level of consumptive use of the hydrologically connected surface water and ground water cannot be sustained in the long term.

6) Aquifer Properties:

(a) *Hydraulic Conductivity* (K) – the volume of water that will flow through a unit cross-sectional area of aquifer in unit time, under a unit hydraulic gradient and at a specified temperature. Basically, K is a measure of how easily water flows through the aquifer. For instance, water flows more easily through a sand and gravel aquifer than an aquifer composed of silts and clays;

(b) *Transmissivity* (T) is the hydraulic conductivity multiplied by the full thickness of saturated aquifer. The more the saturated thickness; the higher the value of T. Saturated thickness is the thickness of the aquifer where all available pore space is filled with water.

River Basins in the UNWNRD

This report focuses on five river basins and sub-basins within the UNWNRD: the Niobrara River Basin, Box Butte Creek Basin, Snake River Basin, White River Basin, and Hat Creek Basin. The following sections of this report present a general description of the following topics for those basins: *1) general description/precipitation/land cover, 2)characterization of surface water flows, 3) surface water appropriations/administration, 4) hydrogeology, 5) ground water wells/development, and 6) analysis/conclusions.* In addition to examining each basin, there will be a brief discussion of where ground water use in the river basin might affect surface water availability outside of the river basin. One separate map deals with all of the basins and is included as a separate insert at the back of the report. That map, developed by the UNWNRD, shows streams that currently have no stream flow according to local residents of the UNWNRD and hydrographers from the DNR. All of the remaining figures for the report are found in Appendix II.

Niobrara River Basin

General Description / Precipitation / Landcover

The Niobrara is the largest river basin in the UNWNRD. *For purposes of this report, Snake Creek and Box Butte Creek, which are part of the basin, are primarily treated in separate sections.* Including Snake Creek and Box Butte Creek, the Niobrara River basin within UNWNRD occupies 2,730,000 acres of land, and runs the full length of the NRD from west to east. Figure 1, Appendix II depicts surface water diversions and surface water basin boundaries in the UNWNRD.

Figure 2, Appendix II presents annual precipitation by year for several UNWNRD weather stations. Overall precipitation for the stations exhibited no statistically significant trends in the fifty to seventy five year periods of record. For the longer period of 1896 to 2003, annual precipitation at the Alliance station in the Niobrara basin has minimum, maximum, and average annual values of 8.67, 25.57 and 16.18 inches respectively.

Land cover in this report has been aggregated for the overall district, rather than by sub-basin. Land cover in the UNWNRD consists primarily of rangeland with dryland crops, forest, and irrigated crops comprising most of the balance (Figure 3). There are also small areas of badlands, lakes, wetlands and urban development. In 1997, irrigated harvested cropland accounted for about 39% of total harvested cropland and 5.4 % of the total land area in the four counties that have land area in the UNWNRD. The primary crops grown in the area are corn, wheat, beans, alfalfa, and sugar beets. In general there are relatively few crops grown in the southeastern and southwestern portions of the district. Box Butte County and areas to the north and east of Box Butte County have more cropped area.

Figure 4 presents U.S. Census of Agriculture information regarding changes in cropland acres, and bushels of production in the four-county UNWNRD area between 1969 and 1997. Harvested irrigated cropland acres increased about 150% while total cropland harvested increased by only about 5% during the period. However, of the two major crops; bushels of corn for grain increased tenfold, while wheat production increased by 181%. These changes are far more significant than those experienced by the state overall, which had a 143% increase in corn production and a nearly 13% decrease in wheat production during the same period.

Characterization of Surface Water Flows

The Niobrara is a perennial stream throughout the study area. Figure 5 depicts the stream and canal network and irrigation wells within the UNWNRD. Figure 6 provides average annual flows on the Niobrara at each gage. The average annual flow leaving the UNWNRD is over 31 times greater the flow entering the UNWNRD at the state line. At the Wyoming State line the Niobrara's flow averaged 2,615 acre-feet per year in the 1956-2002 time period. Above Box Butte Reservoir it averaged 20,334 acre-feet per year (1947-2002) and below the reservoir (after evaporation) it averaged 17,018 acre-feet per year (1947-2002). Approximately seven miles downstream of Box Butte Reservoir the Mirage Flats Canal, the Potmesil Canal, and the Lichte Canal diverted an annual combined average of 16,758 acre-feet from the river in the 1956 to

2002 time period. (Note: these figures are somewhat deceptive because they are long-term averages and flows and diversions by these canals have been decreasing through time). In eastern Sheridan County, south of Gordon, the Niobrara's flow averaged 82,489 acre-feet per year between 1946 and 1994.

Annual average streamflows at the four gaged Niobrara River sites have declined significantly since initiation of measurements between 1946 and 1956 (Figures 7 through 14). One interesting side note is that, for the state line gage only, the maximum decline in streamflow at the state line gage seems to have occurred in the mid- 1970s with levels actually rising since that time.

Surface Water Appropriations/Administration

The Niobrara River in the UNWNRD can be subdivided into two reaches, the reach above the Mirage Flats Canal headgate and the reach below the headgate. There has been an order granting a moratorium on the issuance of new surface water appropriations from the Nebraska-Wyoming state line to the headgate of the Mirage Flats Canal (seven miles below Box Butte Reservoir)in the SENW of Section 26, Township 29 North, Range 48 West of the 6th P.M. in Dawes County since November 30, 1990.

Sixty three of the 144 surface water rights in the Niobrara Basin in the UNWNRD are for the portion of the basin upstream of the Mirage Flats canal diversion. The oldest surface water right in the Niobrara Basin dates to 1883 and there are a total of 81 surface water rights downstream of the Mirage Flats Diversion, including those in the Box Butte and Snake Creek Basins.

Some rights are administered in almost all years to supply water for the Mirage Flats diversion's 1937 water right. The Department of Water Resources order *(November 30, 1990)* granting a moratorium in the Niobrara Basin above the Mirage Flats headgate noted: *"Department records show that Box Butte Reservoir has completely filled only once in the last 25 years. For the benefit of Box Butte Reservoir and Mirage Flats Canal, water administration of upstream junior appropriators occurs every year. The hydrologic experience since Box Butte Reservoir was completed in 1945 gives no indication that greater flows can be expected. Public interest is not well served by granting 'paper water rights'."* Downstream of Box Butte Reservoir, administration has not been required on the mainstem of the Niobrara.

Diversions to the Mirage Flats Canal averaged 17,497 acre-feet per year during the 1948 to1975 time period and 14,172 acre-feet per year during the 1976 to 2003 time period; a 19% decrease (Figure 15). Diversions to other canals in the basin have also decreased (Figures 16 and 17).

There are eight surface water rights along the Niobrara itself between the Mirage Flats canal diversion and the confluence of Box Butte Creek. One of these is for a storage right immediately downstream of the Mirage Flats diversion. The other seven rights are natural flow irrigation rights with four of them being held by one party. The irrigation rights total 13.58 cfs and 950.8 acres with priority dates from 1953 to 2003. There has been no water administration in this reach. Neither have there been calls for administration to the east of Box Butte Creek.

Hydrogeology of the River Basin

(Note: This section also contains general regional geologic/hydrologic information relevant to the Box Butte Creek and Snake Creek Basins)

The principal aquifer units include the Arikaree group and the Ogallala group. In some areas the Sandhills overlie the Ogallala group. Figure 18 provides a geologic map of the district. Figure 19 provides a ground water regions map. The source of water in the study area is primarily local precipitation and underflow of ground water from the west.

The Arikaree Group, which is at the surface in the western and northern portion of the basin, consists mostly of very fine to medium grained sand, sandstone and silt. It also underlies the Ogallala to the east. The Arikaree is a major aquifer in the UNWNRD supplying water to large capacity irrigation wells as well as other depletive water wells in the UNWNRD. Wenzel et. al. (1946) stated that "On the table lands of Sioux and Box Butte counties the sandstones of the Arikaree group yield moderately large amounts of water to wells that penetrate a great thickness". Bradley (1956) indicated that the Arikaree is only moderately permeable. Many irrigation wells have been drilled into the Arikaree since that time.

The Ogallala Group is at the surface and thickens toward the eastern part of the study area. The Ogallala Group includes the Box Butte, Sheep Creek and Runningwater Units. The thickness of the aquifer reaches over 800 feet in the eastern part of Sheridan County. The Ogallala Group consists of gravelly sand, sand, siltstones, and clay. Quaternary sands overlie the formation and absorb precipitation and transmit it downward to the underlying Ogallala deposits. This Group is also a major aquifer in the UNWNRD supplying water to large capacity irrigation and other types of water wells. The Ogallala will yield water to wells more readily than an equivalent thickness of Arikaree or Brule. Depth to water varies greatly in the Sandhills because of the dunes. In many areas it reaches or approaches the surface as lakes, wetlands or subirrigated areas. However, in other areas it may be 300 feet or more to water from the top of a dune.

Geologic cross-section E-E', figure 20, shows the predominant aquifer trends from the Arikaree Group to the Ogallala Group, west to east across the southern portion of the UNWNRD. This cross-section also shows that these two groups are in contact, meaning ground water can move between the two geologic groups. Cross-Sections A-A', B-B' and C-C', figures 21 to 23, depict the geology from south to north at 3 separate locations moving from west to east across the UNWNRD. A-A' shows the Arikaree to be the aquifer in contact with the Niobrara River in the west of the UNWNRD. B-B' is in the zone where the Arikaree and Ogallala aquifers are both present and the Ogallala is in contact with the Niobrara River. C-C' is located in the easternmost part of the UNWNRD and shows the Ogallala with the Quaternary Sandhills deposits overlying it, in contact with the Niobrara River. These two major aquifers, the Arikaree and Ogallala, which supply ground water to numerous irrigation wells in the UNWNRD are also the aquifers in hydrologic contact with the Niobrara River and supply the Niobrara and other perennial streams in the basin with baseflow.

The Brown Siltstone unit, also referred to as the "Beaver Wall" siltstone beds, is in hydrologic contact with the Niobrara River alluvium along an area from the western to central Box Butte County (Souders, 1981). Although the permeability of this Brown Siltstone unit is low; the unit does contain water and is a source of water supply for stock and domestic wells in the northern part of the county (Souders et. al. (1980). According to Souders "Irrigation wells could probably be developed in the unit if a considerable thickness, about 300 ft. (91 m), is penetrated and the wells are developed over a long period of time by surging, back-flushing, and over-pumping. On the whole, the unit is not attractive as a source of water supply if a well yield greater than a few hundred gallons per minute is required". Souders, et. al., also indicated that water moves through this Brown Siltstone unit at the edge of the tableland to the Niobrara Valley. Underflow may be on the magnitude of 1,500 acre-feet (1.85 x 10(6) m(3)) per year. From west to east across northern Box Butte County the major hydrologic unit in contact with the Niobrara River Valley alluvium transitions from the Brown Siltstone to more permeable formations or units of the Ogallala Group that have a higher hydraulic conductivity (Cross-sections A-A' through D-D', Figures 24-27).

Saturated thickness in the study area ranges from the previously mentioned 800 feet in part of Sheridan County to an area where the principal aquifer, as defined by the Conservation and Survey Division (CSD), which does not include the Brown Siltstone Unit, is absent or very thin along the Niobrara in the western portion of the Dawes-Box Butte County line. Aquifer thicknesses in some of the heavily developed areas of Box Butte County are in the 200 to 400 foot range. Saturated thickness is presented in Figure 28. Transmissivity in the study area also varies greatly with the highest transmissivities occurring in southern Sheridan, southern Box Butte, and far west central Sioux counties.

A 1956 U.S. Geological Survey report (Bradley) on the Upper Niobrara Basin indicated that ground water moves in an easterly direction and toward the perennial streams, probably at a rate of less than 1 foot per day (pg. 1). The generalized direction of flow is more varied at the detailed level within the study area. A ground water mound in southeast Sheridan County shows ground water flow moving in all directions away from the top of the ground water mound, north toward the Niobrara River, south to the North Platte Basin, east through the Loup Basin and even west prior to eventually turning north (Figures 29, 30, and 31).

According to water table contour maps and other publications ground water discharge in the Niobrara River Basin occurs through the Niobrara River and its tributaries, lakes, subirrigated areas (ET), and ground water pumping/irrigation (Souders, 1981; Souders et al, 1980). In Box Butte County Souders et. al. estimated that total ground water underflow exiting Box Butte County was 21,000 acre-feet per year, with another 1,500 acre-feet being discharged to springs, seeps, the Niobrara River, Box Butte Creek, and Snake Creek. Of the 21,000 acre-feet of ground water underflow leaving Box Butte County, the majority of that water, about 13,000 acre-feet per year, went north and east to Dawes County, toward the Niobrara River. Also approximately 4,000 acre-feet of ground water was estimated to move northeast into Sheridan County, toward the Niobrara River and Box Butte Creek.

Understanding the total water balance of a basin helps determine the major stresses on the system and how those stressors interact. This in turn helps in understanding how changes to these stressors ultimately impact the total available ground water supply and the resultant baseflow to streams. Significant factors in determining the water balance of the region are precipitation, evaporation, transpiration and recharge. Average annual precipitation in the Upper Niobrara White NRD ranges from 14.9 inches in southern Sioux County to 18.38 inches in eastern Sheridan County. Most precipitation is received during May, June and July and precipitation is highly variable from year to year. Alliance receives over 79% percent of its annual rainfall from April to September. Thus a great deal of the precipitation arrives at times when it is more subject to evapotranspiration.

Evapotranspiration in areas of shallow water table can significantly influence the water balance of a region. Souders, et. al. (1980), indicated large areas of shallow water table in Box Butte County as of 1938.

Estimates of recharge vary and are dependent upon many factors including "the time of year precipitation occurs, the duration and intensity of rainstorms, the freezing and thawing of the soil column, the wetting and drying of the soil column, the slope of the land, the vegetative cover, cultural practices on the land, biological activities of plants and animals in the soil, the texture and permeability of the soil columns, and the vertical hydraulic conductivity of subsoil strata in the unsaturated zone as well as the hydrologic unit occurring at the surface" (Souders et. al., 1980).

Pettijohn and Chen (1984) provided mapped average annual recharge estimates for Box Butte County that ranged from less than .05 inches to 2.5 to 3.0 inches. The Revised Ground Water Management Plan for the Upper Niobrara-White Natural Resources District (Jacobson Helgoth Consultants 1994) indicated that additional information was needed to prepare more meaningful recharge estimates for the entire UNWNRD so that a better water budget model could be created for the district.

Additionally, increases in crop production would suggest that crop evapotranspiration in the district has probably increased. Significant unknown factors in the water balance of the basin include changes in crop water use efficiency (especially for dryland crops), changes in evapotranspiration salvage, and changes in total crop production on ground water irrigated acres versus all other acres.

<u>Ground Water Wells/Development</u>

The Niobrara Basin has about 2,057 active irrigation wells and 49 high capacity wells (500 gallons per minute or more) used for non-irrigation purposes. Irrigation wells in the UNWNRD portion of the Niobrara Basin increased from 1,161 at the beginning of 1980 to 1,536 at the beginning of 1990 to 2,057 by February 29, 2004. There are approximately 115 irrigation wells within a seven mile buffer of the Niobrara River above the Mirage Flats diversion and approximately 125 irrigation wells in the Niobrara River surface water basin above the Mirage Flats Diversion. Figure 32 provides a map of irrigation well locations as well as information on water level changes since predevelopment. Figure 33 supplies the information at a larger scale for the eastern part of the district. Excluding the Box Butte Creek and Snake Creek Basins there are approximately 990 active irrigation wells downstream of the Mirage Flats diversion in the Niobrara River Basin. As of March 20, 2003 the UNWNRD placed a moratorium on the construction of new wells with a capacity of more than 50 gpm.

Figures 34 through 39 provide cumulative depletive and irrigation well numbers through time as well as cumulative surface water appropriation acres through time for the UNWNRD. Of the 49 high capacity non-irrigation wells in the Niobrara River Basin, 22 were for public water suppliers, 13 were for livestock and 9 were for commercial/ industrial purposes. It should be noted that while surface water irrigated acres in the Niobrara River Basin portion of the UNWNRD have been at a near plateau since 1960, the number of ground water irrigation wells in the same region have grown from 302 to 2013 and the associated ground water acres have grown from 53,000 to 317,000 since 1960.

Figure 32 indicates that substantial ground water level declines have occurred in Box Butte County since 1946, in places reaching more than 50 feet. Figure 40 shows readings from an Alliance recorder well within the area of declines that indicate the depth to water had increased by approximately 40 feet between June 1968 and June 2002. Based on the 2003 CSD decline map the edges of the area of decline have reached within 1 mile of the Niobrara River.

Figure 41 provides evidence of water level changes from a recorder well in the Mirage Flats area. The recorder well shows an initial rise in ground water levels following initiation of observation in the early 1950s through the early to mid 1970s, followed by falling levels since that time. Other recorder wells in the area with measurements beginning in the 1970s also show declines. Figure 32 indicates portions of the area have now experienced substantial water level declines from predevelopment. Figures 42, 43 and 44 indicate averages from some observation wells in the southern and northern portions of the Mirage Flats Area. They indicate a steeper decline in the northern portion of the district, with more modest declines to the south, nearer the river.

Niobrara River Upstream of the Mirage Flats Diversion

<u>Analysis</u>

In recent history the Niobrara River has been administered every year to meet the 1937 water right for the Mirage Flats Canal.

The amount of surface water available for diversion from the Niobrara River upstream of the Mirage Flats canal diversion has significantly decreased. At the state line the five-year average flow decreased by 567 acre-feet between the 1956-1960 time period and the 1996-2000 time period. The average flow for the same time periods above Box Butte Reservoir decreased by 4,332 acre-feet. This indicates that although there are significant decreases in average flow at the state line, there are considerably larger decreases after the river enters the state. Records also show that diversions to the Mirage Flats Canal averaged 19% less per year during the 1976 to 2003 time period than during the 1948 to 1975 time period.

River reach gains during the 1956 to 2002 time period were also analyzed for the reach of the Niobrara between the Wyoming-Nebraska State line gage and the gage above Box Butte Reservoir (Figure 45)[1]. Reach gains declined significantly even though during the same period the precipitation at the nearest station, Agate, showed no significant decreasing trend. During this

[1] The analysis involved examining flow at both gages, subtracting gaged diversions (gaged diversions have rights to approximately 84% of the acres irrigated with surface water rights in the reach), and holding remaining water rights constant through time for purposes of analysis.

same period there was a significant increase in the number of wells in the reach. Regression analysis determined that precipitation has a significant positive contribution toward explaining the variance of the gain while the number of irrigation wells has a negative contribution. Almost 79% of the variations in the gains can be explained by these two factors, with numbers of irrigation wells and local precipitation accounting for 62% and 17% of the variation respectively.

Wells in aquifers that are in hydrologic connection with the Niobrara River have increased significantly over time as have their associated irrigated acres. Within a seven mile buffer of the river reach, the number of active irrigation wells has increased from 24 in 1960 to 115 at present. Significant ground water level declines are currently occurring in the aquifer to the south of the Niobrara River in Box Butte County and the edges of the decline area are approaching the river. Based upon the CSD 2003 decline map, it appears that a portion of that decline is affecting the ground water that flows toward the reach of the Niobrara.

The hydrogeology of the Niobrara Basin in the UNWNRD indicates that these declines are in aquifers that are in hydrologic connection to the Niobrara River. Even in western Box Butte County where the low permeable Brown Siltstone Unit lies between the alluvial aquifer of the Niobrara River and the Arikaree and Ogallala aquifers to the south, the presence of sufficient water to supply domestic wells indicates that there is a hydrologic connection between all these formations and the Niobrara River.

Conclusions

In summary, for the reach of the Niobrara upstream of the Mirage Flats diversion: there has been a moratorium on new surface water appropriations since 1990, flows have diminished, surface water diversion amounts have diminished, average precipitation amounts have not significantly changed, and the number of irrigation wells hydrologically connected to the stream reach have increased. Water table declines are evident in Box Butte County in aquifers that are in hydrologic connection with the surface waters of the river reach.

The level of surface water supplies is insufficient to sustain the beneficial purposes for which surface water rights on the reach were granted. Based upon hydrogeologic information the aquifers along the Niobrara River above the Mirage Flats Diversion are hydrologically connected to the river reach. Ground water use is depleting the ground water supply in the aquifers. Where wells are depleting aquifers in hydrological connection to a river, the wells will cause depletions to streamflow in the river. Impacts of the wells closest to the river would be expected to cause relatively more significant and quicker impacts to flows. Where present the low permeability of the Brown Siltstone decreases the impacts of declining ground water levels to the south on the Niobrara River; however, without further information, the potential for these impacts on streamflow in the Niobrara River cannot be discounted. Further study of the impact of the Brown Siltstone unit on the potential of wells in aquifers to the south to impact the river should be a component of any integrated surface water/ ground water plan for the basin.

Mirage Flats Area / Niobrara River from Mirage Flats Diversion to Confluence of Box Butte Creek

<u>Analysis</u>

There appears to be a sizeable reach gain above the Mirage Flats Diversion Dam. In the 1995 to 2003 time period the annual flow of the Niobrara River below Box Butte Reservoir was 13,500 acre-feet and 13,800 acre-feet was removed seven miles further downstream at the Mirage Flats diversion. Since more is being diverted downstream than is being released at the reservoir, the river must be gaining baseflow through this reach in the summer. Additionally, measurements taken by the DNR during the non-irrigation season indicate a monthly reach gain of around 720 acre-feet between the reservoir and the Mirage Flats diversion. It is reasonable to expect some of this reach gain is present during the irrigation season, but the exact amount is unknown.

In an effort to determine more about the current status of this reach of the river DNR staff made spot measurements of streamflow on September 16, 2004 and interviewed several appropriators along the reach. Flow levels found were as follows:

Location	Name	CFS
Nio. Riv. Below Box Butte Reservoir		0.79 cfs
Sec 26-29-48	Nio. Riv below Mirage Flats Div Dam	9.33 cfs
Sec 19-29-45	Nio. Riv. Above Box Butte Cr	12.20 cfs
Sec 29-29-45	Box Butte Cr where it discharges into Nio. Riv	.30 cfs
Sec 20-29-45	Nio. Riv. Below Box Butte Cr	13.80 cfs

All the tributaries located between the Mirage Flats Diversion Dam and Box Butte Creek were dry.

Although there are no long-term flow data, the presence of a reach gain above the diversion dam and between the Box Butte Reservoir and the gage at Gordon, Nebraska, along with the September 2004 DNR measurements suggest that this section of the river is a gaining reach.

There are eight irrigation rights for a total of 13.58 cfs along the reach, most in the lower end of the reach. Comments from interviews with irrigators in this area indicated that currently appropriations in this reach were being satisfied but that flows had decreased in recent years and that some subirrigated wet meadows were no longer wet. One appropriator also indicated that during the summer the river would flow at about half the level it was flowing at the time he was interviewed. There is no record of any administration for the surface water rights in this reach.

This reach of the river is near the irrigated lands of the Mirage Flats Irrigation District and in its downstream end is subject to the impacts of the irrigation district on surface water return flows and baseflow to the river. Figure 15 shows long-term declines in surface water diversions to the Mirage Flats Canal. The data show an overall long term downward trend. Since irrigation wells in the Mirage Flats area are dependent upon recharge from that project, the total supply available to wells is also affected. Because of surface water recharge from the project, water table levels in the area rose until the early to mid-1970s and then began to fall. A USGS report indicated that in 1962, prior to the time when the ground water levels began falling, about 3,000 acre-feet of ground water was pumped in the Mirage Flats project area, which was probably less than the average annual amount of seepage from the project to the zone of saturation (Keech, 1964).

NDNR records indicate that in 1962 there were 51 active irrigation wells in a broadly delineated area that encompasses the Mirage Flats District. As of July 2004 there were 217 active irrigation wells in that area (Figure 46). Most of the wells in the Mirage Flats District are located several miles from this river reach. There are 77 irrigation wells within 2 miles of the river throughout this reach. Eighteen of the irrigation wells are on the south side of the river and, of the 59 on the north, 50 are also in the broadly delineated Mirage Flats region included on the map (Figure 47). It is likely that the additional consumptive use of the ground water wells is now greater than the average annual seepage from the surface water irrigation project and is causing the ground water level declines.

The saturated thickness of the principal aquifer in the Mirage Flats area is estimated to be between 200 and 300 feet with higher levels generally being to the south and east. Figure 26 shows direction of ground water flow to be toward the river and indicates ground water from the southern portions of the Mirage Flats project area is reaching the Niobrara River upstream of the confluence of Box Butte Creek. There have been water level declines in wells along the southern portion of the Mirage Flats area near the river, although not as significant as the declines in the northern portion of the Mirage Flats area (Figure 43). Based upon the reach gain estimates it seems likely that despite ground water level declines in part of the project area, ground water continues to provide baseflow to the river in this reach. It is also important to note that this river reach is hydrologically connected to the aquifer in Box Butte County where there are significant ground water level declines. At this time there are insufficient data available to know the exact amount and timing of any baseflow reaching this river reach or how the ground water level declines might be affecting the baseflow. The installation of a stream gage station and monitoring wells along with other studies to gather data would help answer these questions.

Conclusions

In summary, at the current time this reach of the river has received no calls for administration. There is little historic stream flow data to show trends in stream flow. Ground water contour maps and stream flow observations show that this reach of the Niobrara River gains baseflow. Water well hydrographs and the CSD decline map show significant ground water level declines in aquifers that are hydrologically connected to this river reach. These gains currently appear to be sufficient to satisfy the surface water rights in the reach but there is some anecdotal information that the flows are declining and that administration could be required in the near future. Long term ground water declines associated with ground water pumping in the Mirage

Flats area are affecting the river, but the magnitude and timing of such effects and whether such effects will adversely impact surface water rights in the reach in the near or distant future cannot be determined without further study.

Confluence of Box Butte Creek to the Eastern Boundary of the Natural Resources District

Downstream of the confluence of Box Butte Creek there are no records of calls for surface water administration and it appears that there is sufficient streamflow to satisfy all downstream rights. This reach would be impacted by any changes in base flow due to development in the Mirage Flats Irrigation District, which could adversely affect the surface water rights immediately downstream.

Box Butte Creek Basin

General Description

Box Butte Creek is a tributary of the Niobrara River that enters the river below the Mirage Flats Canal headgate and drains approximately 247 square miles. The Creek originates east of Hemingford, flows toward the southeast for about 10 miles, and then turns towards the northeast and Sheridan County. After entering Sheridan County it turns north toward the Niobrara River.

Cady et. al. (1946) noted that in the 1930's in Box Butte County, Box Butte Creek was a perennial stream except near the eastern portion of the county near the Sheridan County line and that in certain moist years even this reach may have been perennial. There are no continuous gaging records for Box Butte Creek. According to numerous observations west of the Sheridan County line, Box Butte Creek is no longer a perennial stream but east of the Sheridan County line the creek still has constant flow. Spot gaging on the creek in 1986 and again in December 2002, a very dry year, found flow near the mouth of the creek with the creek becoming dry about ½ mile further upstream. In 2002 there was also ponded water at a point a number of miles upstream and cattails at points along the stream. For further general information relevant to the Box Butte basin, including information on precipitation, land cover, and aquifers see the Niobrara River Basin section of this report.

Surface Water Appropriations/Administration/Characterization of Surface Water Flows

Six of the seven surface water rights in the Box Butte Creek basin, with priority dates from 1950 to 1989, are on the mainstem; two are storage rights. In a 1979 adjudication of surface water rights, a number of rights in Box Butte basin were cancelled. Nebraska Department of Natural Resources personnel at one time received calls for surface water rights administration along Box Butte Creek but are no longer asked to administer. It is possible that the lack of calls for administration in recent years is due to a recognition on the part of water right holders that no water is available.

Hydrogeology

(Note: for general geology and hydrology, see the corresponding section on the Niobrara Basin).

Cady (1946) reported that ground water in the northern third of the Box Butte County drained into the lowlands of the Niobrara, either directly, or through Box Butte Creek. In the western area of the Box Butte Creek basin the Box Butte Unit, a thin very clayey silt layer, acts as a confining layer and causes a perched water table where present (Souders et al, 1980). The Sheep Creek Unit mantles the Box Butte Unit in much of the basin. This unit is not a major aquifer; however, it has been reported that some shallow stock and domestic wells obtain their water supply from this unit where it is saturated due to the perched water table caused by the Box Butte Unit (Souders et al, 1980). It is likely that the perched water table in the Sheep Creek Unit is the source of baseflow for Box Butte Creek in its upper reaches. At the Box Butte – Sheridan County line the Box Butte Unit is at considerable depth, 200+ feet, and overlain by the Runningwater Unit. Additionally, Testhole 7-B-79 from Souders (1981) indicates that the Box Butte Unit is either no longer present or no longer contains as high of a percentage of clay east of the Box Butte – Sheridan County line near Box Butte Creek, meaning it is no longer an effective confining layer.

The Runningwater Unit has a saturated thickness of more than 100 feet where Box Butte Creek crosses the Box Butte – Sheridan County line. The Runningwater, which is composed of sand and gravel stream deposits, is estimated to be able to yield enough water to develop 400 to 800 gpm irrigation wells (Souders et al, 1980). The water table contours indicate Box Butte Creek gains water from this unit from the Box Butte – Sheridan County line to its confluence with the Niobrara River. The Box Butte, Sheep Creek and Runningwater Units are considered to be part of the Ogallala Group, which is what is shown on the geology map (Figure 18).

Ground Water Wells/Development

The surface water basin of Box Butte Creek includes 155 active registered irrigation wells. Figure 32 indicates both the location of irrigation wells in the district and the substantial ground water declines that have occurred in much of the subbasin. These declines are in aquifers that are hydrologically connected to Box Butte Creek.

Conclusions

Stream flow in Box Butte Creek has declined since the 1930's. Wells in the basin are contributing to changes in ground water levels in aquifers that are hydrologically connected to Box Butte Creek. The consumptive use from ground water wells has caused or will cause depletions in Box Butte Creek and has adversely affected surface water rights in the basin.

Snake Creek Basin

General Description

In the 1930's and 40's Snake Creek was a perennial stream with a small discharge, except during floods, that arose in eastern Sioux County and ran in an easterly direction across the southern portion of Box Butte County before losing itself in a broad lowland 3 or 4 miles wide near Alliance (Cady, et. al. (1946). In a 1980 report Souders, et. al. (1980) stated that Snake Creek flowed year round from west of the Box Butte County line to east of Kilpatrick Lake and that east of there it was an ephemeral stream. Other information in that report indicates that at that time Snake Creek had areas of shallow water table along its lower reach and that to some degree the lowering of the water table by pumping had salvaged evapotranspiration in some of that area. Today Snake Creek only flows west of Kilpatrick Lake.

The watershed is a part of the Niobrara Basin, although the Creek did not have any surface water connection to the Niobrara River. There are other similar streams in this area including Point of Rocks Creek (a Snake Creek tributary) and nearby Hemingford Creek and Berea Creek, which dead-end into the western portion of the Sandhills. Souders et. al. (1980) identified these three streams as being ephemeral. These creeks flow generally northwest to southeast, ultimately dead-ending on the western portion of the Sandhills. For further information relevant to the Snake Creek Basin and precipitation and land cover in the basin, see the section on the Niobrara River Basin.

Surface Water Appropriations/Administration/Characterization of Surface Water Flows

There are currently five surface water rights associated with the Snake Creek Basin. Two of those are associated with Kilpatrick Reservoir, one with Kilpatrick Canals and two with Snake Creek tributaries. Two rights are for storage, two for irrigation, and one for supplemental irrigation. Priority dates range from 1894 for the Kilpatrick canals and 1911 for Kilpatrick Reservoir to 1970 and 1973 for the water rights on the tributaries.

Administration has not occurred in the Snake Creek Basin since the early 1970s. This may be in part because the three rights on Snake Creek proper are all for Kilpatrick Reservoir and canals and the other two rights have no rights upstream of them. Thus there are no other rights to call on.

There are no gages on Snake Creek. Spot measurements showed flow above Kilpatrick reservoir in 1983, although not in 1986 or 1987. There are also reports of wetlands in the area. Thirty years ago it was not unusual to measure 4 to 6 cfs of inflow to the reservoir compared to current measurements of 1 to two cfs range (Hayden, 2002). At one time the basin also contained Bronco Lake, which has been dry for some time. In 2004 it was reported for the first time that Kilpatrick Reservoir was dry. Snake Creek has ceased to flow below the Kilpatrick Reservoir. For all practical purposes, only above Kilpatrick Reservoir can Snake Creek be called a live stream.

Hydrogeology

Details on the hydrogeology near these creeks can be found in the hydrogeology discussion within the Niobrara River Basin. In short, the Arikaree and Ogallala groups are hydrologically connected to Snake Creek and are capable of producing water for large capacity irrigation wells. The configuration of the water table continues to show ground water flow moving toward the stream as it approaches the area of the stream.

Ground Water Wells/Development

Snake Creek basin currently has 780 active registered irrigation wells. Approximately 767 of these wells are within a five-mile distance of the creek. Figure 5 indicates the location of irrigation wells in the district along with the stream network. Heavy pumping of ground water wells in the area has resulted in ground water levels falling by about 30+ feet in northern portions of the Snake Creek Basin, averaging 1 foot of decline per year since 1960. The edges of the decline area now reach beyond the Snake Creek subbasin and into the Niobrara River Basin as well as out of the UNWNRD and into northern Morrill County in the North Platte Natural Resources District (Figure 32).

Conclusions

Ground water pumping in the basin has contributed to declines in streamflow in Snake Creek to the degree that the only portion of Snake Creek that exists as a live stream is above Kilpatrick Reservoir.

White River Basin and Hat Creek Basin

General Description

The White River Basin and Hat Creek Basin include 247 square miles in the northern portion of the Upper-Niobrara White NRD. Figure 3 presents land cover for the overall UNWNRD. Precipitation information for Chadron is provided in Figure 2. Annual precipitation at the Chadron station has minimum, maximum, and average annual values of 8.45, 23.16, and 15.92 inches respectively for the period of 1949 to 2003. There have been no significant long-term trends for precipitation in the basin. Information on precipitation and land use in the basin can be found in the discussion on the Niobrara River Basin.

Surface Water Appropriations/Administration/Characterization of Surface Water Flows

The oldest surface water right in the White and Hat basins dates to 1880 and there are a total of 527 surface water irrigation rights in the area. Of those, 296 rights are for the White River Basin, and 231 rights are for the Hat Creek Basin. About 25% of the rights in the basin are storage rights. Many small dams have been built on tributaries for the purpose of watering livestock. Figure 1 provides a map of surface water diversions throughout the UNWNRD. Figure 48 provides cumulative surface water appropriations in the basin, and Figure 49 provides surface water appropriation acres by use. The White River Basin contains 1,620 square miles in Nebraska and the Hat Creek Basin contains 474 square miles.

The basins support one surface water irrigation district and a large number of individual irrigation rights. Whitney Reservoir diverts water from the White River downstream from Crawford and provides water to the Whitney Irrigation District. Surface waters in the study area also support other uses. The upper reaches of the White River, Hat Creek and their tributaries support one of Nebraska’s best cold-water fisheries. Crawford’s municipal water supply comes from wells in the White River alluvium. Although they have wells, both Crawford and Chadron also have surface water rights associated with their municipal water systems.

Surface water rights in both the Hat Creek and White River basins are administered in most years. There has been an informal moratorium and new surface water rights have been denied in both basins since 1995 due to insufficient flow.

Sando (1991) estimated and characterized what would have been natural streamflow without irrigation depletions on the White River near the Nebraska state line and found there would have been flow in every month in the 1976 to 1989 time period with average annual flows ranging from 14,654 acre-feet to 69,173 acre-feet (pg. 18). Sando indicated that the White River in Nebraska generally flows year round. However, some locations in some years experience periods of no flow. He also noted that streamflow generally was not sufficient to fully satisfy the net irrigation requirement for all irrigators during the later part of the irrigation season (pg. 11).

The White River does have continuous flow at a gage at Crawford and its gaged annual flows average 14,719 acre-feet and have remained fairly constant through time. There is a gage on the White River at Crawford that shows no significant trend on flows since 1931 (Figure 50). This may be a reflection of the commitment of flows at Crawford to downstream water rights.

While there is no Nebraska gage on Hat Creek, there is a gage on Hat Creek some distance into South Dakota near Edgemont. No significant flow trend is apparent for that gage during the 1951 to 2002 time period.

Hydrogeology

The aquifers in these basins are nearly nonexistent. Geologic cross-sections A-A' and B-B' (Figures 21 & 22) show the Arikaree Group as the primary unit in the western upper reaches (southern area of the basins) of the river basins. This is the same Arikaree Group aquifer that is found in the Niobrara River Basin and whose geologic properties were discussed in the earlier section of this report on the Niobrara River Basin. The Pine Ridge forms the surface water divide between waters that flow to the Niobrara to the south, and the White and Hat Creek basins to the north. While a ground water divide is also found along the Pine Ridge it is important to remember that a ground water divide is not permanent and that the direction of ground water flow can be influenced by stresses to the system.

Looking at the same cross-sections mentioned above, moving north from the Pine Ridge, lower geologic units are found at the surface, the Arikaree is literally cut off in these basins where it has eroded away and relatively impermeable materials are at the surface. The geologic units below the Arikaree and that outcrop progressively to the north are, in order, the Brule, the Chadron, and the Pierre Shale. None of these geologic units are considered major sources of ground water. The Brule is a tight formation composed primarily of silts and clays and has a minimal hydraulic conductivity of less than 25 feet per day (Olsson Associates, 1993). In some areas there may be a significant saturated thickness that contains a great deal of water; however, the hydraulic conductivity of unfractured Brule is very low (Wenzel, et al., 1946).

The Chadron consists mostly of massive silty claystones, light brownish to pink in color. These rocks owe their origin in large part to extensive deposits of volcanic ash, now mostly devitrified into clays. Occasionally discrete beds of volcanic ash can be found in the Chadron. Some channel sandstones may be present. A coarse sandy unit is often found at the base of the Chadron. The Chadron is similar to the Brule, it is tight and has a low hydraulic conductivity except in fractures or in the sand beds which are limited in areal extent. The Chadron rests on the Pierre throughout most of northwestern Nebraska.

The Pierre Shale is predominantly a dark gray or brownish-gray shale, but also contains thin beds of bentonite, zones of calcareous concretions, and some shaly limestones. The Pierre, which crops out over most of the northern part of the Hat and White Basins, is considered impermeable. It is found at the surface in the west and is overlain again by younger, more permeable formations in the far eastern areas of the Hat and White Basins. This unit is very tight and is not considered to hold any extractable ground water except where there are extensive fractures in contact with a source of water such as an alluvial valley.

The principal aquifer, the Arikaree, is recharged by precipitation and inflow from the western edge of the UNWNRD. Streams and tributaries that begin in this relatively permeable material on the Pine Ridge have perennial flow maintained by ground water baseflow in the upper reaches but ground water contribution effectively ceases once the streams flow over other geologic units. Bentall and Hamer (1980) in reference to Hat Creek, the White River, White Clay Creek, and their tributaries indicated that it was unknown whether any of these streams in their natural state flowed continuously as far as the South Dakota state line. They noted that they now become dry before they reach the state line because many impoundments reduce inflow from tributaries and diversions for irrigation consume all the remaining flow.

Fractures in the otherwise relatively impermeable Brule formation supply water for some stock and domestic wells as do the Chadron sands. At a few specific sites, where fracture systems intersect faults, this formation contributes up to 600 gallons per minute from springs (Jacobson-Helgoth Consultants, 1994). There are also some river deposited sediments along the major drainages. In their lower reaches the streams may be in hydrologic connection with small amounts of alluvial material, Chadron sands or fractures in the Pierre Shale or Brule Formation, but overall there is little ground water available for high capacity uses outside the upper reaches of the basin.

Based upon geologic cross-sections A-A' and B-B' (Figures 21 & 22), water table contour maps and other evidence, Hat Creek, White River and some of their tributaries are hydrologically connected to ground water in their upper reaches. The ground water source is the same Arikaree Group aquifer that is hydrologically connected to the Niobrara River; therefore, changes in stressors in either river basin could affect the baseflow to streams in the other basins. Outside the extent of the Arikaree, there is an absence of aquifers. However, where the other geologic formations provide water to small capacity wells, it is likely the formation through fractures is in hydrologic connection with a stream and/or alluvial aquifer.

Ground Water Wells/Development

There are only 24 registered irrigation wells in the White River and Hat Creek basins and 14 of these were in place prior to 1970. Only three new registered irrigation wells have been completed since 1980. Over 720 other types of depletive wells have been installed in the basin since 1989, but generally the amounts of depletion per well are low in comparison to irrigation wells. There are only 3 large capacity wells pumping more than 500 gallons per minute that are not irrigation wells. Figure 5 provides a map of irrigation wells throughout the district along with the stream network.

There are very few large capacity wells in these basins. This is mainly due to the topography and hydrogeology in the area. The alluvial areas are very small and lie on Pierre Shale and the Brule Formation, both of which are very tight and do not yield water to wells unless a fracture system is tapped.

Conclusions

Due to the nature of the geologic formations in the area the ground water supply in the White and Hat basins is limited. It seems likely that most wells have a hydrologic connection to surface water and would affect surface water appropriations; however, some may be in fractures that have little or no known connection to surface water. Given that the study area has insufficient surface water to grant new appropriations, some monitoring of ground water development trends will be needed to be certain that increased well development does not further deplete already insufficient streamflows.

Because the baseflow for streams in this area originates in the southern margins of the basin along the Pine Ridge, it is possible that ground water development just outside the physical surface water basin could affect baseflow in the headwaters of some streams such as Larabee Creek and possibly Beaver Creek and White Clay Creek, all of which have active surface water rights. The impact of well development outside the surface watershed boundary on the flow of these creeks should be monitored.

Potential Out of Basin Effects of Water Use In the UNWNRD

To what extent could the ground water declines in Box Butte County affect the North Platte River or its tributaries? A very small portion of the North Platte Basin surface water drainage reaches into the UNWNRD in the southern margins of Box Butte, Sioux, and Sheridan counties. Ground water subflow for a very small portion of Southern Sheridan County is hydrologically connected to the North Platte Basin. Ground water table contours indicate that this area provides baseflow to Blue Creek. However, this is an area where there is not a high gradient and there are many lakes and wetlands that influence ground water flow via evapotranspiration. With these localized complications, the direction of subflow can be difficult to determine.

Based on water table contour maps, the far southwest corner of the UNWNRD also appears to have ground water subflow towards the North Platte Basin, but there is only one irrigation well in that area. Between this area and the North Platte River lies the Brule Formation, an area of low transmissivity and hydraulic conductivity. The magnitude and timing of any declines originating from development in this area would be long term.

An additional potential impact that could occur due to ground water pumping in the Niobrara Basin/Sandhills area might involve the alkali lakes in the southeast portion of the UNWNRD. Should water table declines in eastern Box Butte County become marked enough, they might influence water table levels further east in the area of the Sandhills lakes.

Water table contours indicate the direction of subflow for ground water in a portion of southeast Sheridan County is towards the Loup River Basin. This area is very far from any stream headwaters and the Loup surface water drainage basin within the UNWNRD contains only five irrigation wells. While there is a hydrologic connection, impacts to surface water appropriators, if any, would be very small, and would likely not be felt for many years.

Parameters Considered in Delineating the Areas Where Ground Water is Considered to be Hydrologically Connected to the Surface Water Reaches

Drawing lines delineating the area of ground water hydrologically connected to a specific reach of a river is a technically complex task. Aquifer boundaries are relatively easy to define where impermeable geological formations outcrop near the surface or a stream that penetrates the full thickness of the aquifer. In absence of such boundaries, ground water table divides or ground water flow lines from the endpoint of the fully appropriated river reach could also be used. However, a ground water well on one side of a ground water table divide can still impact a stream on the other side of the divide and if the ground water table declines significantly, the location of the ground water table divide itself will change. Surface water boundaries generally are not useful for determining ground water flow, but in some instances the surface water divide does provide a major influence on ground water flows and mimics the location of the ground water divide.

As defined in this report the river reaches that are recommended to be designated as fully appropriated are the full reaches of the White River and Hat Creek, the Niobrara above the Mirage Flats diversion, Box Butte Creek and Snake Creek.

In the White River and Hat Creek, the live sections of the streams are in the headwaters and are in hydrologic connection with the Arikaree aquifer, which continues into the Niobrara River Surface Water Basin. Possible boundaries in this area include the ground water and surface water divides. However, the situation exists where ground water well development outside of these boundaries could affect baseflow in the stream reaches of concern. Hydrologically speaking, there is a continuous aquifer from the Niobrara River to the headwaters of the White River and Hat Creek. However, as distance increases away from the headwaters the degree of connection decreases.

One way to measure the degree of connection is to use a stream depletion calculation (Jenkins, 1977). Based upon existing data concerning transmissivity and specific yield the following stream depletion lines were calculated: 28% over 40 years - 2.5 to 5 miles from the upper reaches of the streams, over 80 years the range is 3 to 7 miles and over 120 years the range is 4 to 8 miles. Some value of stream depletion could be chosen as the boundary for the area in which ground water is hydrologically connected to the stream reach.

In the Niobrara River basin near the Mirage Flats diversion point there is a stream (Cottonwood/Pebble Creek) located on the north side of the River; however, there is no reason to believe that this stream fully penetrates the aquifer. Another option is this area would be to follow a ground water flow line north from the diversion point to where it intersects the boundary with the White River. The ground water flow line would be even less of a hydrologic boundary than the stream.

To the south of the Niobrara River the situation is more complex. The question raised above, of the effects of ground water declines across a ground water divide is applicable. According to the ground water level decline maps developed by the CSD in Box Butte County, a 20’ to 30’ decline has occurred at the ground water divide between the Niobrara Basin and the Snake and Box Butte Creek basins. Moving from the ground water divide north toward the Niobrara River the 5’ to 10’ decline zone reaches to within a mile of the Niobrara River. There is question as to the degree of hydrologic connection between the decline area and the Niobrara River due to the presence of low permeability geologic materials. However, as was mentioned previously, Souders et al (1980) stated that this material does contain enough water to produce wells of 600+ gallons per minute and that a possible 1,500 acre feet per year of ground water flow reaches the river above Box Butte Reservoir. Given the evidence and the severity of the ground water level declines any possible effect on the fully appropriated river reach must be considered.

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Appendix I

February 26, 2003

John Burke, Chairperson
Upper Niobrara White NRD
430 East 2nd Street
Chadron, NE 69337

Dear Mr. Burke:

This letter is to notify your district that in accordance with the requirements of section 46-656.28 (2), R.R.S., 1998, I have made a preliminary determination in response to your written request of January 10, 2003. My determination is that there is reason to believe that the use of hydrologically connected ground water and surface water resources in the Upper Niobrara White Natural Resources District is contributing to or is in the reasonably foreseeable future likely to contribute to conflicts between ground water users and surface water appropriators.

In order to make this preliminary determination Department staff reviewed the records of the Department; the District's ground water management plan, rules and regulations; ground water monitoring records; the Department's "Hydrographic Reports"; the USGS "Water Resources Data – Nebraska" showing stream flow, canal diversions and ground water levels; the Department's "Biennial Reports" showing surface water appropriations; and the ground water well registration data. Other resources reviewed include the following: Geology and Ground-Water Resources of Box Butte County, Nebraska, USGS Water-Supply Paper 969; Ground-Water Resources of Mirage Flats, Nebraska, USGS Water-Supply Paper 1779-BB; Geology and Groundwater Supplies of Box Butte County, Nebraska, Nebraska Water Survey Paper Number 47. On January 23, 2003, Tom Hayden wrote a memo documenting the decline in the surface water flow of Box Butte Creek, Snake Creek, and Antelope Creek from the time he started working for the Department until current day.

Based on this review we determine that:

1. There have been concerns about declining surface water flows resulting from the increased ground water pumping throughout the District, most notably in the Niobrara River Valley. A letter to the Governor dated October 19, 2002, echoed these concerns. The District also provided a list of concerns the public has regarding declining surface and ground water levels. These events have prompted the District to take action on conjunctive use to try to avoid further conflicts.

2. The Department published notice and issued a formal order declaring a moratorium on new surface water rights along the Niobrara River above Box Butte Reservoir. The Department has also denied applications in the White River and Hat Creek Basins since approximately 1993 on the basis that there is insufficient unappropriated water; effectively placing a moratorium on the White River and Hat Creek Basins.

3. The Department's database on water well registrations show that the number of new irrigation water wells constructed annually within the Upper Niobrara White NRD hit a peak in 1976 then declined until 1988 and rebounded to an average of 30 new wells completed per year until 2003. As of February 5, 2003, the total number of completed irrigation wells in the District was 2,038. (Figures 6 – 8)

4. The District is underlain by unconsolidated to consolidated, very fine to coarse-grained sediments which were deposited primarily in alluvial and eolian environments. These sediments comprise the different aquifers found throughout the District. Ground water from these sediments is the primary source of flow for the Niobrara River and other streams in the District. The relationship between the aquifers and surface water is most readily apparent in the Mirage Flats area and in Box Butte County. Within the Mirage Flats area, a locally significant rise in the water table corresponds to the delivery of surface water through the canals. The resultant ground water mound has been declining in recent years most likely due to the increased pumping in the area. In Box Butte County, heavy pumping of ground water for the past several decades has resulted in a significant decrease in the water table. This decrease appears to correspond with the declining flows in several of the streams that drain the county. Prior to the extensive development of ground water pumping, Snake Creek was identified as a perennial stream fed primarily by ground water. It is now an intermittent stream.

5. Monitoring wells reported by the USGS on their online database show ground water declines in various wells in the District. (Figures 1 – 5)

The above findings support a preliminary determination that there is reason to believe that the use of hydrologically connected ground water and surface water resources is contributing to or is in the reasonably foreseeable future likely to contribute to a conflict between ground water users and surface water appropriators. Accordingly, Ann Bleed is authorized to work with the District to conduct studies to determine the extent and precise cause of the conflict.

Sincerely,

Roger K. Patterson
Director

tk
Enclosures

Upper Niobrara-White
Natural Resources District
430 East 2nd Street
Chadron, Nebraska 69337
Telephone (308) 432-6190 http://dbdec.nrc.state.ne.us/unwnrd/ Fax (308) 432-6187

January 10, 2003

RECEIVED
JAN 13 2003
DEPARTMENT OF
[illegible]URCES

Mr. Roger Patterson, Director
Department of Natural Resources
P.O. Box 94676
Lincoln NE 68509

Dear Mr. Patterson,

Ground water levels within the Upper Niobrara White Natural Resources District have steadily declined for over 30 years. Declines in ground water levels have subsequently affected surface water; streams where there used to be surface water appropriations no longer carry water to appropriate. For example, Bronco Lake located west of Alliance is completely dry.

Surface water that is transported via canal to the Mirage Flats Irrigation District in Sheridan County is affecting the ground water in the area. Monitoring and observation well information from Mirage Flats indicate the effect in variable water levels and water temperature.

Therefore, we believe it would be in the best interest of the public to establish an integrated management area to manage these waters. With this letter, the Upper Niobrara White Natural Resources District requests, under the Nebraska Ground Water Management and Protection Act (section 46-656.28), that the Department of Natural Resources consult with the Upper Niobrara White NRD; and that studies and a hearing be held on the preparation of a joint action plan for the integrated management of hydrologically connected ground water and surface water.

Sincerely,

John Burke, Chairman

Surface Water Rights in the Upper Niobrara White Natural Resou

Application	Annotation	Carrier	Priority Date			Use [1]	Grant [2]	Rate [3]	S
A Jordan Lower Reservoir									
A 3446	A-3446	Lower Jordan Canal	2	28	1941	6	0		1
A 5212	A-5212	Allen Jordan Pump	2	28	1941	6	0		1
A Jordan Reservoir									
A 5212		Jordan Canal No. 1	8	23	1940	5	0		1
A 3446		Jordan Canal	8	23	1940	5	0		
Alkali Creek									
A 9889		Ormesher Corner Reservoir	2	17	1961	2	36 AF		2
Anderson Reservoir									
A 4976		Pump	4	18	1950	5	0		2
A 3396		Anderson Canal	10	16	1940	5	0		
A 4861		Anderson Canal 1-2	8	19	1949	5	0		
Andrews Reservoir									
A 9815		Pump	3	26	1935	5	0		
A 4464		Andrews Canal	3	26	1935	5	0		
A 2558		Andrews Canal	3	26	1935	5	0		
Antelope Creek									
A 5124		Hull Canal No. 4	1	5	1953	1	1.14	70	2
A 3239		A Jordan Reservoir	8	23	1940	2	776 AF		
A 10551		Antelope Creek Res. 40-B	3	3	1965	2	774 AF		2
A 5168		Hull Canal No. 1	2	17	1953	1	0.04	70	2
A 5172		Hull Reservoir	2	17	1953	2	2.3 AF		2
A 5170		Hull Canal No. 5	2	17	1953	1	0.17	70	2
A 5169		Hull Canal No. 6	2	17	1953	1	0.94	70	2
A 5171		Hull Canal No. 2	2	17	1953	1	0.47	70	2
Antelope Creek, North									
A 1509		Story Canal	3	26	1918	1	6.43	70	
A 168		Story Canal	11	11	1895	1	2		
Antelope Creek, South									
A 17252		Eitel Reservoir No. 1	2	24	1993	2	14.9 AF		3
A 14743		Pumps 1-3	2	18	1977	1	0.34	70	1
D 537		Turner Canal	10	31	1894	1	0.86	70	2
A 1675		Turner Reservoir	7	3	1922	2	250 AF		2
A 338		Ellis Canal	5	17	1896	1	0.29	70	

Application	Annotation		Carrier	Priority Date			Use [1]	Grant [2]	Rate [3]	S
Antelope Creek, South, Trib. To										
A 3775			Schnurr Reservoir No. 2	10	10	1944	2	123 AF		2
A 10151			Story Canal No. 3	2	27	1963	1	3.74	70	1
A 4907			Dunlap Reservoir No. 1	9	18	1951	2	16 AF		1
A 6415			Dunlap Reservoir No. 2	7	8	1954	2	20 AF		1
Antelope Creek, Trib. To										
A 10550			Antelope Creek Res. 60-A	3	3	1965	2	446 AF		2
A 4502			Anderson Reservoir	8	19	1949	2	65 AF		
A 8942			Holzberger Reservoir	10	30	1956	2	43 AF		2
A 3405			A Jordan Lower Reservoir	2	28	1941	2	137 AF		1
Ash Creek										
A 5281			Pump	4	24	1953	1	0.29	70	
Ash Creek, East										
A 2024			Barron Canal	8	15	1928	1	0.89	70	3
D 438			Barron Canal	7	1	1888	1	1.14	70	3
A 2057			Thomas Canal	12	17	1928	1	1	70	1
A 1953			Norman Reservoir	8	22	1927	2	776 AF		3
A 16376			Barron Canal	5	6	1985	1	1.68	70	3
A 2205			Stumph-Ox Yoke Canal	6	6	1931	1	0.26	70	3
D 1023	R		Stumph Canal	9	5	1892	1	0.22	70	3
D 447	R	P-160	Stumph Canal	5	31	1880	1	0.16	70	3
Ash Creek, East, Trib. To										
A 17013			Hollibaughs Fish Ponds	8	17	1990	2	8.28 AF		2
A 11803			Ham Fish Pond	9	23	1969	2	2.2 AF		
A 4760			Ivins Reservoir	10	30	1950	2	25 AF		3
Ash Creek, West										
A 16042			Pump	12	24	1981	1	0.09	70	1
A 12905			Pump	7	17	1973	1	0.19	70	1
D 452	R	P-NONE	West Ash Creek Canal	7	4	1893	1	0.8	70	3
A 434	R	P-350	West Ash Creek Canal	2	3	1898	1	0.57	70	3
A 5973	R		West Ash Creek Canal	2	18	1954	1	3.26	70	3
A 12744			Pump	9	22	1972	1	0.06	70	3
A 17417			Soester Reservoir	11	8	1994	2	67.7 AF		
A 3362	R	P-349	West Ash Creek Canal	1	6	1941	1	1.31	70	3
Badland Reservoir										
A 8704		A-5986	Badland Canal	7	23	1952	6	0		
A 8704			Badland Canal	7	23	1952	5	0		

Application	Annotation	Carrier	Priority Date	Use[1]	Grant[2]	Rate[3]	S
Bauer's Lone Tree Reservoir							
A 6916		Bauer's Lone Tree Canal	9 23 1953	5	0		2
Beaver Creek							
A 5081		Isham Reservoir	11 24 1952	2	435 AF		1
A 15795		Pump	3 20 1981	1	3.19	70	2
A 2034		Lockler Canal	9 19 1928	1	0.49	70	3
D 1017		Lockler Canal	9 15 1892	1	1.83		3
A 6400		Kadlecek Reservoir	6 30 1954	2	70 AF		3
A 4932		Pumps	1 15 1952	1	0.14	70	2
A 16118		Pump	6 4 1982	4	0.02		3
Beaver Creek, Little							
A 16117		Pump	6 3 1982	4	0.03		2
A 4608		Lundy Reservoir	2 27 1950	2	222 AF		3
A 4933		Pump	1 15 1952	1	0.03	70	2
A 6686	A-4608	Lundy Reservoir	9 13 1954	8	47 AF		3
A 5154		Reeves Reservoir	2 9 1953	2	0.5 AF		2
Bodarc Springs							
A 4765		Zimmerman Reservoir	11 9 1950	2	26 AF		2
Boggy Creek							
A 2182		Wickersham Reservoir	12 24 1930	2	250 AF		3
A 2204		Wickersham Canal	5 15 1931	1	0.96	70	3
A 701		Wickersham Canal	2 28 1903	1	3	70	3
A 4918		Wickersham Res. No. 2	11 7 1951	2	42 AF		3
Boggy Creek, Middle							
A 342		Marten Canal	5 19 1896	1	0.36	70	1
Boggy Creek, West							
A 886		Hill Canal	1 20 1908	1	0.86	70	1
A 4639		Holmgren Reservoir	4 11 1950	2	43.1 AF		[illegible]
Bordeaux Creek, Big							
A 1748	R P-323	Pump	9 12 1924	1	0.16	70	3
A 2036	R P-286	O'donnell Canal	9 22 1928	1	0.63	70	9
A 432	R P-285	O'donnell Canal	1 17 1898	1	0.14	70	9
A 5202		Pump	3 10 1953	1	3.55	70	9
A 2151		Pump	7 24 1930	1	0.1	70	1
A 2801		Pump	11 16 1937	1	0.21	70	1
A 9428		Pump	4 4 1957	1	1.71	70	2
A 15796		Pump	3 23 1981	1	1.62	70	2
A 5447		Pump	8 4 1953	1	0.43	70	3

Application	Annotation	Carrier	Priority Date			Use[1]	Grant[2]	Rate[3]	S
A 7648		Pump	6	10	1955	1	0.39	70	3
A 2328		Pump No. 2	7	7	1933	1	0.03	70	1
A 5008		Pump	8	11	1952	1	1.72	70	1
A 3891		Bass Nursery Canal	4	11	1946	1	0.99	70	2
A 17281		Pump	4	29	1993	1	0.23	70	1
A 5631		Pump	10	7	1953	1	1.4	70	1
A 5129		Pump	1	13	1953	1	2.7	70	
A 7043		Pump	1	25	1955	1	0.02	70	2
A 15835		Pump	4	8	1981	1	0.33	70	1
Bordeaux Creek, Big, Trib. To									
A 4761		Pine Springs Reservoir	11	3	1950	2	2 AF		2
Bordeaux Creek, Little									
A 15836		Pump	4	8	1981	1	0.85	70	1
A 8984		Pump	11	19	1956	1	2.01	70	3
A 8345		Pump	2	3	1956	1	2.27	70	1
A 16931		Pump	2	26	1990	4	0.33		1
BOX Butte Creek									
A 7710		Pump	6	15	1955	1	0.71	70	3
A 15619		Pump	2	19	1980	1	0.71	70	3
A 4690		Pump	6	5	1950	1	0.9	70	3
A 4692		Heaton Reservoir	6	6	1950	2	44 AF		3
A 16830		Reservoir No. 1	6	19	1989	2	5.3 AF		1
A 12126		Pump	12	16	1970	1	2.03	70	3
BOX Butte Creek, Trib. To									
A 12098		Pump	10	9	1970	1	2.28	70	1
BOX Butte Reservoir									
A 6565	A-2683	Mirage Flats Canal	8	5	1954	6	0		2
A 6565	A-3729	Mirage Flats Canal	8	5	1954	6	0		2
Caladonia Reservoir									
A 1681		Caladonia Canal	7	20	1922	5	0		1
A 1683		Caladonia Canal	7	20	1922	5	0		1
A 1683	D-543	Caladonia Canal	7	20	1922	6	0		1
Carter P Johnson Reservoir									
A 16114		Pump	6	2	1982	5	0		
Cedar Creek									
A 9775		Little Red Reservoir	10	6	1959	2	48 AF		2
D 507		Schilt-Cedar Creek Canal	5	15	1885	1	0.57	70	3
A 3172		Grote Reservoir	6	4	1940	2	19 AF		

Application	Annotation	Carrier	Priority Date			Use[1]	Grant[2]	Rate[3]	S
D 976		Valdez Canal	4	5	1886	1	0.5	70	1
Chadron Creek									
A 17349		Pfister Res. No. 1	2	2	1994	2	1.53 AF		
A 2007		Chadron State Park Lake	4	17	1928	2	10 AF		3
A 9842		Chadron Reservoir No. 2	7	19	1960	2	143 AF		1
D 1022		Chadron Water Works	12	31	1888	4	1		1
A 1583		Chadron Water Works	4	8	1920	35	4.5		1
A 14076		Pump	3	3	1976	1	0.77	70	1
A 9975		Pump	9	7	1961	1	1.11	70	
A 11626		Pump	1	28	1969	1	0.3	70	
A 10970		Pump	10	14	1966	1	0.02	70	3
A 16932		Pump	2	26	1990	4	0.09		1
A 13094		Pump	7	23	1974	1	4.26	70	2
A 17343		O Rourke Res. No. 1	12	22	1993	2	1 AF		1
A 17350		Pipeline	2	2	1994	7	1		
A 17342		Pipeline	12	22	1993	7	1		1
A 13815		Pump	9	18	1975	1	1.56	70	1
Chadron Creek, Trib. To									
A 4526		Mayfield Reservoir	10	19	1949	2	73 AF		2
Charcoal Creek									
A 11393		Pump	4	15	1968	1	0.05	70	3
A 3130		Charcoal Canal	4	2	1940	1	0.13	70	3
Cherry Creek									
A 3909		Merlo Reservoir	5	21	1946	2	15 AF		2
D 549		Cherry Creek Canal	5	1	1893	1	0.03	70	2
Cherry Creek, Trib. To									
A 3844		Serres Reservoir No. 2	6	18	1945	2	54 AF		2
A 3843		Serres Reservoir No. 1	6	18	1945	2	27 AF		3
Coffee Reservoir No. 1									
A 4937		Lickett Canal	7	17	1951	5	0		2
A 4937	A-549	Lickett Canal	7	17	1951	6	0		2
Cornelius Jordan Reservoir									
A 1469	A-841	Cornelius Jordan Canal	1	14	1915	6	0		1
A 841	A-841	Cornelius Jordan Canal	11	12	1906	6	0		1
A 1470	A-1375	Kite (neil) Canal	1	14	1915	6	0		1
Cottonwood Creek									
A 8721		Pump	8	6	1956	1	2.3	70	1

Application	Annotation	Carrier	Priority Date	Use [1]	Grant [2]	Rate [3]	S
Cottonwood Creek, Big							
A 15759		Moody Reservoir No. 1	1 29 1981	2	265 AF		3
A 14395		Pump	8 13 1976	1	3.53	70	2
Cottonwood Creek, Big, Trib. To							
A 9689		Norman Reservoir No. 3	2 16 1959	2	170 AF		1
A 4930		Norman Reservoir No. 2	1 8 1952	2	935 AF		[illegible]
A 5037		Moody Reservoir	9 26 1952	2	143 AF		2
A 3580		Norman Reservoir No. 1	7 6 1942	2	150 AF		3
Cottonwood Creek, Little							
A 1276		Dodd-Mcdowell Reservoir And Pipeline	4 15 1913	2	480 AF		1
D 425	R P-NONE	Stuart Bros. South Canal	12 21 1890	1	0.36	70	1
A 8	R P-220	Stuart Bros. South Canal	6 10 1895	1	1.43	70	1
A 2363		Simons Canal	2 12 1934	1	0.77	70	9
A 17323		Dodd-Mcdowell Canal	10 13 1993	1	2.65	70	1
A 8	R P-NONE	Stuart Bros. North Canal	6 10 1895	1	1.43	70	1
A 649		Dunn Canal	1 14 1902	1	1.43	105	[illegible]
Cottonwood Creek, Little, Trib. To							
A 4905		Speas Reservoir	9 8 1951	2	14 AF		
A 10307		Pump	2 13 1964	1	1.04	70	9
A 10306		Pump	2 13 1964	1	0.64	70	9
Coyote Springs							
A 2572		Coyote Springs Reservoir	4 1 1936	2	15 AF		1
A 2418		Watson Canal	7 7 1934	1	1.41	70	1
Coyote Springs Reservoir							
A 2579	A-2418	Coyote Springs Canal	4 1 1936	6	0		1
A 2579		Coyote Springs Canal	4 1 1936	5	0		1
Crystal Lake Reservoir							
A 8035		Crystal Lake Canal No. 2	8 26 1955	5	0		[illegible]
A 2286		Crystal Lake Canal	8 22 1927	5	0		[illegible]
Dan Jordan Reservoir							
A 2072		Dan Jordan Canal	2 20 1929	5	0		3
Dawes-Sheridan Creek							
A 12876		Mirage Flats Reservoir	5 30 1973	2	19.6 AF		2
Dead Horse Creek							
A 17218		Dead Horse Creek Pond	8 19 1992	7	1		[illegible]
A 749	R P-306	Pump No. 1	4 6 1904	1	0.56	70	3
A 749	R P-306	Pump No. 2	4 6 1904	1	0.44	70	3
A 16890		Scherbarth Pond No. 2	10 23 1989	2	2.65 AF		3

Application	Annotation	Carrier	Priority Date			Use[1]	Grant[2]	Rate[3]	S
A 5065		Pump	11	5	1952	1	0.6	70	
A 749	R P-246	Pump	4	6	1904	1	0.95	70	
A 9790		Pump	1	19	1960	1	0.76	70	
A 17217		Scherbarth Pond No. 3AB&C	8	19	1992	2	1.5 AF		
A 4786		Pump	1	10	1951	1	1.48	70	
A 2021	R P-281	Pump	6	15	1928	1	0.55	70	
A 4911		Pump	9	24	1951	1	0.03	70	
Dead Man Creek									
A 17384		Pipeline	7	12	1994	7	0.89		
A 17383		Double Cross Ranch Res. No. 1	7	12	1994	2	2.28 AF		
A 14435		Pine Ridge Pond	8	30	1976	2	3 AF		
Deep Creek									
A 6814		Pump	11	22	1954	1	0.58	70	
A 17408		Double Cross Ranch Res. No. 2	9	29	1994	2	9 AF		
A 17409		Pipeline	9	29	1994	7	0.89		
Deer Creek									
A 4466		Pump	4	19	1949	1	1.85	70	
Dodd Reservoir									
A 10312		Hazelton Canal	2	21	1964	5	0		
A 10312	D-475	Hazelton Canal	2	21	1964	6	0		
Dodd-Mcdowell Reservoir									
A 1571	A-1276	Dodd-Mcdowell Canal	4	15	1913	6	0		
Dorshorst Reservoir									
A 5630		Dorshorst Canal	11	14	1952	5	0		
Dout Reservoir No. 1									
A 2000	A-5985	Dout Canal No. 1	4	2	1928	6	0		
Dout Reservoir No. 2									
A 2002	A-5986	Dout Canal No. 2	4	2	1928	6	0		
Dry Canyon									
A 1481		Betson Canal	3	22	1917	1	1	70	
Dry Creek									
A 2608		Baldwin Reservoir	8	11	1936	2	332 AF		
A 2608		Pilster Reservoir	8	11	1936	2	363 AF		
Dry Draw									
A 1475		Heath Reservoir	2	7	1917	2	200 AF		
Dunlap Reservoir									
A 9981		Dunlap Canal	11	5	1951	5	0		
A 7861		Dunlap Canal	8	4	1955	5	0		

Application	Annotation		Carrier	Priority Date			Use [1]	Grant [2]	Rate [3]
Dunlap Reservoir No. 2									
A 7861			Dunlap Canal	8	4	1955	5	0	
Eberspecher Reservoir No. 1									
A 3896			Eberspecher Canal	9	10	1945	5	0	
Eberspecher Reservoir No. 2									
A 4903			Eberspecher Canal	4	11	1950	5	0	
English Creek									
A 9869		A-2064	Mcdowell Lake No. 3	10	17	1960	8	17 AF	
A 2064			Mcdowell Lake No. 1	1	22	1929	2	36.2 AF	
A 772			Mcdowell System	10	24	1904	1	3	70
A 2064	R	P-365	Mcdowell Lake No. 3	1	22	1929	2	5.05 AF	
Geike Creek									
A 1967			Geike Canal	11	4	1927	1	0.43	70
A 4752			Geike Reservoir	10	3	1950	2	5 AF	
Geiser Reservoir									
A 3439			Geiser Canal	10	4	1940	5	0	
Golf Course Pond									
A 17110			Pump	9	11	1991	5	210 AF	
Grote Reservoir									
A 3450			Grote Canal	6	4	1940	5	0	
A 3451		D-976	Grote Canal	6	4	1940	6	0	
Harris Reservoir									
A 1996			Harris Canal	9	29	1922	5	0	
Hat Creek									
A 1236			Coffee Flood Canal	10	22	1912	1	5.36	70
A 3922			Semroska Canal	7	2	1946	1	0.43	70
A 17044			Whispering Pines Pipeline	1	18	1991	7	0.28	
A 17045			Whispering Pines Ponds	1	18	1991	2	9.1 AF	
A 15592			Pumps	10	11	1979	1	2.35	70
A 341			Miller Canal	5	19	1896	1	0.37	70
D 512			Coffee Canal	9	1	1881	1	4.29	70
A 5089			Pump	11	28	1952	1	3.96	70
A 3291			Pump	10	11	1940	1	0.66	70
A 15996			Pump	9	24	1981	1	0.42	70
Hat Creek, Trib. To									
A 3281			Vyzourek Reservoir No. 2	10	7	1940	2	7 AF	
A 3279			Geiser Reservoir	10	4	1940	2	28 AF	
A 9640			Bill Coffee Canal	8	20	1958	1	1.59	70

Application	Annotation		Carrier	Priority Date			Use [1]	Grant [2]	Rate [3]	S
A 9639			Bill Coffee Res. No. 1	8	20	1958	2	63 AF		3
A 4647			Semroska Reservoir	4	21	1950	2	44 AF		
A 3343			Vyzourek Reservoir No. 3	12	6	1940	2	4 AF		2
Hat Creek, West										
D 553	B	T-968	West Hat Creek Canal	5	31	1886	1	0.57	70	1
D 553	A	T-967	West Hat Creek Canal	6	1	1880	1	0.43	70	1
Hawk Nest Reservoir										
A 3818		A-3536	Moody Canal No. 1	12	8	1941	6	0		3
Hay Creek										
A 4501			Wallace Reservoir No. 2	8	18	1949	2	109 AF		1
Hay Springs Creek										
A 2539			Barnes-Phillips Res.	4	15	1935	2	12 AF		
A 2549			Walgren Lake	5	20	1935	2	890 AF		2
Hay Springs Creek, North Branch										
A 3053		A-2549	Walgren Lake	12	15	1939	8	0		1
Hay Springs Creek, Trib. To										
A 4378			Linden Reservoir	11	26	1948	2	49 AF		
A 11457			Davis Reservoir	6	21	1968	2	18.5 AF		2
Heath Reservoir										
A 1612			Heath Canal	2	7	1917	5	0		1
Henry Reservoir No. 1										
A 4830			Henry Canal No. 1	5	17	1950	5	0		1
Henry Reservoir No. 2										
A 15532		A-4830	Henry Canal No. 5	7	30	1979	6	0		3
A 4829			Henry Canal No. 2	5	17	1950	5	0		3
Hooker Creek										
A 803			Alcorn Reservoir	11	17	1905	9	1.01	70	3
A 4864			Souther Reservoir	5	19	1951	2	41 AF		3
Horse Head Creek, Trib. To										
A 4747			Snook Reservoir	9	18	1950	2	32 AF		2
A 17193		A-4747	Snook Reservoir	6	8	1992	8	10.5 AF		2
Hull Reservoir										
A 5614			Hull Reservoir Canal	2	17	1953	5	0		2
Indian Creek										
A 6159		A-4830	Mader-Henry Canal	4	1	1954	6	0		2
A 1952			Norman Canal	8	18	1927	1	1.28	70	1
A 1614			Norman Canal	8	3	1921	1	0.69	70	1
A 15944			Pump	7	20	1981	1	0.26	70	2

Application	Annotation	Carrier	Priority Date			Use[1]	Grant[2]	Rate[3]	S
A 5608	A-4578	Mader Reservoir No. 2	9	26	1953	8	0		2
A 5610	A-4680	Henry Reservoir No. 1	9	26	1953	8	0		2
A 4004		Meier Canal	11	14	1946	1	0.69	70	2
A 5607	A-3983	Mader Reservoir No. 1	9	26	1953	8	0		2
A 5612		Mader-Henry Canal	9	26	1953	1	2.88	70	2
A 15797		Pump	3	23	1981	1	1.41	70	2
A 9797		Jerome Mader Canals 1-2	2	18	1960	1	1.87	70	2
A 1704		Norman Canal	1	17	1923	1	0.67	70	1
A 9779		Geiser Canal No. 2	12	7	1959	1	0.44	70	2
A 8739	A-4578	Mader Reservoir No. 2	8	10	1956	8	190 AF		2
A 5611	A-4829	Indian Creek Canal	9	26	1953	6	0		2
A 5609		Indian Creek Canal	9	26	1953	1	0.51	70	2
Indian Creek, Trib. To									
A 4680		Henry Reservoir No. 1	5	17	1950	2	48 AF		1
A 10729		Trotter Canal No. 1	12	9	1965	1	0.59	70	1
A 9843		Merlin Mader Res. No. 1	7	20	1960	2	115 AF		2
A 4925		Wiedenfeld Res. No. 1	1	2	1952	2	92 AF		2
A 4527		Mader Reservoir No. 3	10	21	1949	2	24 AF		2
A 3962		Wallace Reservoir	9	16	1946	2	39 AF		2
A 13442	A-4680	Henry Reservoir No. 1	2	25	1975	8	115 AF		1
A 3983		Mader Reservoir No. 1	10	15	1946	2	148 AF		2
A 4578		Mader Reservoir No. 2	1	25	1950	2	84 AF		2
A 4679		Henry Reservoir No. 2	5	17	1950	2	46 AF		3
Indian Tree Creek									
A 3537		Hawk Nest Reservoir	12	8	1941	2	17 AF		3
A 3536		Moody Canal	12	8	1941	1	0.74	70	3
A 16001		Moody Reservoir No. 2	9	28	1981	2	80.5 AF		3
Ivins Reservoir									
A 4948		Ivins Canal	10	30	1950	5	0		3
Jim Creek									
A 5986		Dout Canal No. 2	2	24	1954	1	0.52	70	[illegible]
A 2274		O'connell Canal	6	20	1932	1	0.35	70	1
A 8703		Clarence Canal No. 2	7	30	1956	1	0.2	70	1
A 2001		Dout Reservoir No. 2	4	2	1928	2	16 AF		[illegible]
D 536		Woodruff South Canal	5	1	1890	1	0.36	70	1
D 981		Dout Brothers Canal	5	15	1889	1	0.86	70	[illegible]
A 1682		High Line Canal	7	20	1922	1	0.34	70	1
A 4696	A-1680	Caladonia Reservoir	6	12	1950	8	13 AF		1

Application	Annotation	Carrier	Priority Date			Use [1]	Grant [2]	Rate [3]	S
A 9471		Dout-Jim Creek Canal	4	26	1957	1	0.41	70	1
D 543		Slattery Canal	5	31	1891	1	0.29	70	1
A 1999		Dout Reservoir No. 1	4	2	1928	2	145 AF		[illegible]
A 8702		Clarence Canal No. 1	7	30	1956	1	0.62	70	1
A 5985		Dout Canal No. 1	2	24	1954	1	2.29	70	[illegible]
A 1680		Caladonia Reservoir	7	20	1922	2	42 AF		1
Jim Creek, East									
A 4520		Staudenmaier Reservoir	10	7	1949	2	44 AF		1
A 3834		Jim Creek Canal	5	17	1945	1	0.27	70	1
A 581		Wasserburger Canal	10	13	1900	1	2.29	70	2
A 3848		Staudenmaier Canal	7	26	1945	1	0.56	70	2
A 10961		Pump	10	5	1966	1	0.38	70	1
Jim Creek, East, Trib. To									
A 3149		Wasserburger Reservoir	5	6	1940	2	45 AF		2
D 984		Homestead Canal	5	31	1890	1	0.21	70	2
A 3853		Eberspecher Res. No. 1	9	10	1945	2	16 AF		2
A 451		Hunter Canal	5	12	1898	1	0.03	70	2
A 9637		Eberspecher Res. No. 1	8	13	1958	2	110 AF		1
Jim Creek, Trib. To									
A 4995		Badland Reservoir	7	23	1952	2	33 AF		[illegible]
A 3358		Snyder Reservoir	12	23	1940	2	45 AF		1
Johndreau Creek									
A 4954		Reynolds Reservoir	3	25	1952	2	5 AF		3
Jones Reservoir									
A 10125		Jones Canal	11	26	1962	5	0		3
A 10125	A-10048	Jones Canal	11	26	1962	6	0		3
Jordan Draw									
A 2071		Dan Jordan Reservoir	2	20	1929	2	200 AF		3
Kilpatrick Reservoir									
A 1159	D-567	Kilpatrick Canals No. 1&2	6	7	1911	6	0		[illegible]
Larabee Creek									
A 10146		Pump	2	18	1963	1	1.64	70	
A 8723		Pump	8	6	1956	1	0.52	70	3
A 10253		Robins Reservoir	10	15	1963	2	3.17 AF		[illegible]
A 15877		Pump	5	26	1981	1	0.71	70	
A 6564		Pump	8	5	1954	1	1.97	70	1
Larabee Creek, Trib. To									
A 4848		Scott Reservoir	4	19	1951	2	3 AF		1

Application	Annotation	Carrier	Priority Date			Use [1]	Grant [2]	Rate [3]	S
A 17075		Glen Forney Reservoir	5	15	1991	2	14.4 AF		[illegible]
Lickett Creek									
A 549	R P-313	Lickett Canal	3	21	1900	1	0.42	70	2
A 4891		Coffee Reservoir No. 1	7	17	1951	2	22 AF		2
Linden Reservoir									
A 4512		Linden Canal	11	26	1948	5	0		
Little Red Creek									
A 9768		Little Red Reservoir	10	6	1959	2	48 AF		2
A 2003		Zerbst Canal	4	3	1928	1	0.9	70	3
Lone Tree Creek									
A 4985		Mcmeekin Reservoir	7	5	1952	2	109 AF		1
A 5597		Bauer's Lone Tree Res.	9	23	1953	2	208 AF		2
Lone Tree Creek, Trib. To									
A 4553		Bauer Reservoir	12	21	1949	2	96 AF		1
A 4676		Benthack Reservoir	5	12	1950	2	13 AF		[illegible]
Long Branch									
A 587		O'connell Canal	11	10	1900	1	0.2	70	2
A 16477		Diversion Dike	3	19	1986	1	0.75		
Lundy Reservoir									
A 6697		Lundy Canal	9	13	1954	5	0		3
Madden Creek									
A 9804		Ormesher Canal	3	24	1960	1	3.74	70	[illegible]
A 1061		Ernest Canal	2	20	1911	1	3.71	70	2
Mader Reservoir No. 1									
A 4236		Mader Canal	10	15	1946	5	0		2
Mader Reservoir No. 2									
A 6982	A-4236	Mader Canals 2 & 6	1	25	1950	6	0		2
Mader Reservoir No. 3									
A 4730		Mader Canals No. 4 & 5	10	21	1949	5	0		2
Mader Reservoirs 1-2									
A 8738	A-4730	Mader Canals 2, 5, 6 & 7	1	25	1950	6	0		2
A 8738		Mader Canals 2, 5, 6 & 7	1	25	1950	5	0		2
Mayfield Reservoir									
A 4629		Mayfield Canal	10	19	1949	5	0		2
Mcmeekin Reservoir									
A 5315		Mcmeekin Canal	7	5	1952	5	0		1
Merlo Reservoir									
A 4087		Merlo Canal No. 1	5	21	1946	5	0		2

Application	Annotation	Carrier	Priority Date	Use[1]	Grant[2]	Rate[3]	S
Messenger Creek, Trib. To							
A 4643		Snook Reservoir	4 17 1950	2	30 AF		3
Monroe Creek							
A 2372		Big Monroe Canal	4 16 1934	1	2.1	70	3
A 4880		Bruce Canal No. 1	7 5 1951	1	0.41	70	1
A 1375		Kite Canal	7 30 1914	1	2	70	1
A 4881		Bruce Canal No. 2	7 5 1951	1	0.21	70	1
D 509		Schlit-Monroe Canal	7 2 1888	1	0.5	70	2
A 2032		Richard Jordan Canal	9 19 1928	1	1.67	70	2
A 1399	A-841	Cornelius Jordan Res.	1 14 1915	8	800 AF		1
D 506		Big Monroe Canal	5 1 1888	1	1.43	70	3
A 83		Noreisch Canal	7 19 1895	1	0.04	70	3
A 841		Cornelius Jordan Canal	11 12 1906	1	2.2	70	[illegible]
A 841		Cornelius Jordan Res.	11 12 1906	2	271 AF		1
Monroe Creek, Trib. To							
A 10201		Lake Ellis	6 12 1963	2	6.08 AF		[illegible]
A 2297		Monroe Reservoir	1 16 1933	2	2 AF		
A 3908		Parsons Reservoir	5 21 1946	2	8 AF		2
A 7451		Wasserburger Res. No. 1	5 9 1955	2	43 AF		2
A 16190		Lake Ellis	4 21 1983	8	7.55 AF		[illegible]
Moody Reservoir No. 1							
A 16000		Pump	9 28 1981	5	0		2
Moody Reservoir No. 2							
A 16111	A-3536	Moody Canals 3,4,5	5 28 1982	6	0		3
A 16111	A-16000	Moody Canals 3,4,5	5 28 1982	6	0		3
A 16111		Moody Canals 3,4,5	5 28 1982	5	0		3
Morris Reservoir							
A 9998		Morris Canal	1 17 1961	5	0		2
A 9998	A-6247	Morris Canal	1 17 1961	6	0		2
A 9998	A-815	Morris Canal	1 17 1961	6	0		2
A 9998	A-3030	Morris Canal	1 17 1961	6	0		2
Musfelt Reservoir							
A 9641		Musfelt Canal	10 31 1956	5	0		3
Ned Painter Reservoir							
A 15410		Pump	1 31 1979	5	0		3
Niobrara River							
A 18015		Iodence Wetland	9 6 2001	2	11.1 AF		2
A 9999		Pumps	11 14 1961	1	2.24	70	2

Application		Annotation		Carrier	Priority Date			Use[1]	Grant[2]	Rate[3]
A 4758	A			Pump	10	19	1950	1	1.34	70
A 4758	B			Pump	10	19	1950	1	4.93	70
A 16598				Pump	10	29	1987	3	0.02	
D 442	A			Pioneer Canals	8	1	1887	1	2.22	85
A 3812		R	P-530	Pioneer Canal No. 2	3	8	1945	1	0.49	70
A 4599				Pioneer Canal No. 3	2	16	1950	1	0.21	70
A 5010				North Pioneer Canal	8	11	1952	1	0.62	70
A 3812		R		Pioneer Canal No. 2	3	8	1945	1	0.28	70
A 16398				Pump	6	14	1985	1	2.2	70
A 5531				Pump	9	1	1953	1	0.78	70
A 1260				Geo. Hitshew Canal	2	17	1913	1	1.76	70
A 8565				Pump	5	15	1956	1	0.24	70
A 9838				Pump	6	26	1960	1	0.53	70
A 4603				Pump	2	23	1950	1	1.79	70
A 2264				Excelsior Canal	3	28	1932	1	1.92	70
D 568				Excelsior Canal	5	15	1895	1	2.86	70
D 566				Mclaughlin Canal	5	1	1888	1	3.69	70
A 9017				Pump	12	5	1956	1	1.16	70
A 4862				Hitshew Canal No. 2	5	17	1951	1	0.6	70
A 12893				Pump	6	28	1973	1	1.04	70
A 88		R	P-305	Moore Canal	7	22	1895	1	5.71	70
D 461		R	P-406	Pumps	1	27	1894	1	0.53	70
A 2555				Pumps	8	9	1935	1	0.96	70
A 2623				Pump	8	25	1936	1	0.34	70
D 514	B			Earnest Canal No. 2	5	15	1891	1	2.14	70
D 987	A			Hughes Canal	5	31	1890	1	0.57	130
A 2523		R	P-396	Lichte Canal	3	2	1935	1	0.77	70
A 2266			T-703	Montague Canal	3	31	1932	1	0.91	115
A 10686				Potmesil Canal	9	7	1965	1	1.59	70
A 9018				Pump	12	5	1956	1	0.77	70
A 2523		R	P-379	Mirage Flats Canal	3	2	1935	1	0.16	70
A 4717				Pump	7	1	1950	1	0.71	70
A 10761				Pump	2	2	1966	1	0.17	70
D 980	A			Cook Canal No. 1	5	31	1891	1	2.31	70
D 980	B			Mcginley-Stover N. & Cook Canal No. 2	5	31	1891	1	0.16	70
D 513	B	R	T-754	Mcginley-Stover S. Canal	5	1	1890	1	1.34	70
D 513	A	R	P-397	Mcginley-Stover N. Canal	5	1	1887	1	5.06	70
D 513	A	R	P-430	Pump	5	1	1887	1	1.48	

Application	Annotation		Carrier	Priority Date			Use [1]	Grant [2]	Rate [3]	S
A 1362	R	P-311	Earnest Canal No. 2	3	24	1914	1	1.46	70	[illegible]
A 1152	R	P-396	Lichte Canal	1	2	1912	1	0.2	70	2
D 554			Lakotah Canal	10	1	1883	1	5.76	70	
D 511	R	P-243	Johnson Canal	5	1	1894	1	2.09	70	3
D 510	R	P-282	Pumps	6	8	1891	1	0.96	70	2
A 2683			Mirage Flats Canal	1	25	1937	1	136	70	2
A 8216			Pump	10	7	1955	1	1.21	70	1
A 2837	R	P-380	Mirage Flats Canal	2	11	1938	1	0.26	70	2
A 10490			Pump	12	21	1964	1	0.66	70	1
A 17398	B		Pump	9	7	1994	1	2.51	70	1
A 17398	A		Pump	9	7	1994	1	2.86	70	2
A 5531	R	P-485	Pump	9	1	1953	1	1.86	70	2
A 10432			Pump	9	3	1964	1	0.96	70	2
A 5840			Pump	1	4	1954	1	1.46	70	2
A 3729			Mirage Flats Canal	5	18	1944	1	30.8	70	2
D 514	A		Earnest Canal No. 1	5	1	1885	1	2.86	70	[illegible]
A 2654			Pump	11	6	1936	1	0.9	70	3
A 10870			Pump	6	20	1966	1	0.39	70	[illegible]
A 5181	R	P-411	Pump	2	24	1953	1	1.1	70	2
A 2709	A		BOX Butte Reservoir	3	6	1937	2	:E+04 AF		2
A 3456		A-2709A	BOX Butte Reservoir	6	24	1941	8	E+04 AF		2
A 5467			Pumps	8	12	1953	1	0.3	70	1
A 7477			Pumps	5	14	1955	1	1.33	70	2
A 16048			Pump	1	13	1981	1	1.02	70	3
A 7971			Pumps	8	22	1955	1	1.05	70	2
A 9572			Pump	9	26	1957	1	1.77	70	2
A 10716		T-702	Montague Canal	11	15	1965	1	0.34	70	2
A 2566	R	P-314	Potmesil Canal	10	29	1935	1	6.2	70	2
A 575	R	T-785	Montague Canal	9	27	1900	1	0.24	437	2
D 980	R	P-428	Pump	5	31	1891	1	0.52	70	
A 1249	R	T-745	Bennett Canal	12	18	1912	1	3.45	70	
A 2275			Harris-Neece Canal	7	11	1932	1	2.54	70	
A 1248			Mettlen Canal	12	18	1912	1	0.5	70	[illegible]
A 292			Mettlen Canal	4	27	1896	1	2.94	70	[illegible]
A 60			Labelle Canal	7	3	1895	1	2.27	70	[illegible]
D 518			Labelle Canal	3	12	1895	1	1.4	70	[illegible]
A 1086	R	P-396	Lichte Canal	4	7	1911	1	1.97	70	2
D 479	R	P-396	Lichte Canal	1	24	1895	1	0.86	70	2

Application	Annotation	Carrier	Priority Date			Use [1]	Grant [2]	Rate [3]	S
A 2244		Mettlen Canal	10	13	1931	1	0.93	70	[illegible]
A 1260	R P-500	Geo. Hitshew Canal	2	17	1913	1	2.76	70	[illegible]
A 3923		Montague Canal	7	11	1946	1	0.43	70	2
D 517		Harris-Neece Canal	7	1	1892	1	7.13	70	
A 1088		Lichte Canal	4	19	1911	1	0.23	70	2
Niobrara River, Trib. To									
A 4644		Anderson Reservoir	4	18	1950	2	157 AF		2
A 3297		Anderson Reservoir	10	16	1940	2	20 AF		[illegible]
A 10954		Frank Reservoir	9	19	1966	2	11 AF		1
A 4540		Peters Reservoir	12	1	1949	2	4 AF		1
A 3337		Wilson Reservoir	11	26	1940	2	7 AF		2
A 18171		Pump	5	30	2003	1	0.74	70	2
Norman Reservoir									
A 2179		Harry Canal	8	22	1927	5	0		
Norman Reservoir No. 1									
A 5290	RES NO. 2	Norman Canal No. 1	4	27	1953	5	0		3
Norman Reservoir No. 2									
A 5290	RES NO. 1	Norman Canal No. 2	4	27	1953	5	0		[illegible]
North Draw Reservoir									
A 3819		Moody Canal No. 2	12	8	1941	5	0		3
North Platte River									
D 828	B	Empire Canal	12	19	1889	1	0.18	70	1
Patton Creek									
A 2845		Pump	3	14	1938	1	0.18	70	3
Peters Reservoir									
A 4727		Pump	12	1	1949	5	0		1
Pine Creek									
A 9124		Pump	1	22	1957	1	0.42	70	2
A 4876		Hageman Reservoir	6	22	1951	2	25 AF		[illegible]
A 4114		Smith Lake Reservoir	9	15	1947	2	3500 AF		1
A 14511		Pump	10	15	1976	1	1.53	70	3
Plunkett Reservoir									
A 2070		Plunkett Canal	9	18	1928	5	0		2
Point of Rocks Creek, Trib. To									
A 12891		Hansen Reservoir	6	25	1973	2	70.7 AF		[illegible]
Prairie Dog Creek									
A 2031		Plunkett Reservoir	9	18	1928	2	110 AF		2
D 551		Zerbst Canal	5	1	1893	1	0.14	70	2

Application	Annotation	Carrier	Priority Date	Use [1]	Grant [2]	Rate [3]	S
A 9774		Little Red Reservoir	11 25 1959	2	149 AF		2
D 508		Schilt-Prairie Dog Canal	5 31 1886	1	1.14	70	3
A 3842		Plunkett Canal	6 14 1945	1	0.36	70	2
A 3737		Plunkett Canal	6 24 1944	1	1.34	70	2
Raben Reservoir No. 1							
A 4586		Raben Canal	2 19 1942	5	0		2
Raben Reservoir No. 2							
A 4868	A-4586	Raben Canal No. 2	1 13 1950	6	0		2
A 4868		Raben Canal No. 2	1 13 1950	5	0		2
Rush Creek							
A 14092		Pump	3 12 1976	1	2.04	70	1
A 706		Braddock Canal	5 4 1903	1	3	87	1
A 5590		Brown Canal	9 22 1953	1	1.14	70	3
A 17673		Brown Ranch Water Control Reservoir	5 6 1998	2	10.7 AF		3
Rush Creek, Trib. To							
A 8946		Musfelt Reservoir	10 31 1956	2	54 AF		3
Sand Creek							
A 11002		Dobesh & Jackson Res.	12 22 1966	2	41.6 AF		2
A 189		Bendix Canal	11 19 1895	1	0.57	70	3
A 1669		Bendix Canal	5 27 1922	1	0.71	70	3
Sand Creek, Trib. To							
A 15363		Ned Painter Reservoir	11 17 1978	2	49.6 AF		3
Saxson Draw							
A 1689		Harris Reservoir	9 29 1922	2	7 AF		3
Schaefer Reservoir No. 1							
A 3557		Leonard Canals 1 And 2	2 27 1933	5	0		[illegible]
Schnurr Reservoir No. 2							
A 3871		Schnurr Canal No. 2	10 10 1944	5	0		1
Semroska Reservoir							
A 4768		Semroska Canal No. 1	4 21 1950	5	0		[illegible]
Serres Reservoir No. 1							
A 3969		Serres Canal No. 1	6 18 1945	5	0		3
Serres Reservoir No. 2							
A 3970		Serres Canal No. 2	6 18 1945	5	0		2
Sheep Creek							
A 885		Horse Camp Res. Ditch	1 20 1908	1	0.43	70	3
A 859		Nebraska Res. Canal	5 18 1907	1	0.57	70	3

Application	Annotation	Carrier	Priority Date	Use [1]	Grant [2]	Rate [3]	S
Shepherd Reservoir							
A 3795	A-1965	Shepherd Reservoir Canal	1 29 1931	6	0		3
Snake Creek							
A 1104		Kilpatrick Reservoir	6 7 1911	2	2300 AF		
D 567		Kilpatrick Canals No. 1&2	6 6 1894	1	54.9	70	
Snake Creek, Trib. To							
A 11904		Pump	3 30 1970	1	1.68	70	
Snyder Reservoir							
A 3445		Snyder Canal	12 23 1940	5	0		1
Soester Reservoir							
A 17448	A-17417	West Ash Creek Canal	4 27 1995	5	5.72 AF		3
A 17448	A-3362	West Ash Creek Canal	4 27 1995	6	9.52 AF		3
A 17448	A-5973R	West Ash Creek Canal	4 27 1995	6	48.3 AF		3
Soldier Creek							
A 16115		Pump	6 2 1982	1	1.06	70	
A 9654		Carter P Johnson Res.	10 13 1958	2	124 AF		
Souther Reservoir							
A 15829	A-15828	Mansfield Canals 1-3	4 6 1981	6	0		3
Sow Belly Creek							
A 9988		Zimmerman Canal	10 3 1961	1	0.91	70	3
A 2530		Andrews Reservoir	3 26 1935	2	42 AF		
D 559		Montgomery Canal	12 1 1890	1	1	70	2
A 11760		Pump	8 5 1969	1	0.72	70	
A 2306	R P-298	Schaefer Reservoir No. 1	2 27 1933	2	54.3 AF		
A 12762		Schaefer Reservoir	11 7 1972	2	17.3 AF		
A 4790		Zimmerman Canal	1 17 1951	1	0.61	70	3
A 15127		Zimmerman Reservoir	10 18 1977	2	26 AF		2
A 5343	T-1172 D-533R	Sow Belly Canal	6 3 1953	1	0.47 CF	698	
D 533	R T-1154P-299	Sow Belly Canal	6 1 1887	1	3 CF	109	
A 532		Zimmerman Canal	1 11 1900	1	0.71	70	3
Sow Belly Creek, Trib. To							
A 3894		Lundy Reservoir	4 17 1946	2	3 AF		2
Spring Branch							
D 557		Tucker Canal	6 1 1883	1	0.17	70	3
Spring Creek							
A 5045		Marcy Reservoir	10 20 1952	2	8 AF		2
A 5069		Dorshorst Reservoir	11 14 1952	2	12 AF		2
A 4741		Marcy Canal	8 28 1950	1	3.37		2

Application	Annotation	Carrier	Priority Date			Use[1]	Grant[2]	Rate[3]	S
A 663		Forbes Canal No. 1	4	28	1902	1	0.43	70	2
A 13736		Pump	8	14	1975	1	2.57	70	1
A 15348		Pump	10	11	1978	1	1.69	70	1
A 13706		Spring Creek Reservoir	8	4	1975	2	202 AF		
A 4904		Spring Creek Reservoir	9	6	1951	2	26 AF		[illegible]
A 2078	D-473	Spring Creek Canal	12	1	1894	1	1.3	70	[illegible]
A 14262		Hawley Pipeline	6	9	1976	1	0.37	70	2
D 1014		Mozeter Canal	5	3	1888	1	1.14	70	1
D 532		Spring Creek Canal	6	1	1893	1	0.29	140	[illegible]
A 1954		Crystal Lake Reservoir	8	22	1927	2	80 AF		[illegible]
A 5705	A-1954	Crystal Lake Reservoir	11	3	1953	8	53 AF		[illegible]
D 550		Hall Spring Canal	3	26	1889	1	0.57	70	[illegible]
D 473		Spring Creek Canal No. 1	12	1	1894	1	2	70	1
Spring Creek Reservoir									
A 15334	A-13736	Pump	8	29	1978	6	0		
A 15334	A-15348	Pump	8	29	1978	6	0		
Spring Creek Reservoir No. 3									
A 4996	D-532	Spring Creek Canals 1 & 2	9	6	1951	6	0		[illegible]
A 4996		Spring Creek Canals 1 & 2	9	6	1951	5	0		[illegible]
Squaw Creek									
A 1132		Squaw Creek Reservoir	10	3	1911	2	200 AF		1
A 333		Cooper Canal	5	8	1896	1	2.29	70	3
A 12743		Pine Ridge Pump No. 1	9	18	1972	1	0.12	70	3
A 1965		Shepherd Reservoir Canal	10	24	1927	1	3.16		3
Squaw Creek Reservoir									
A 1631		Squaw Creek Canal	10	3	1911	5	0		1
Squaw Creek, South									
A 4779		Thomas Canal	12	19	1950	1	0.47	70	1
A 2189		Shepherd Reservoir	1	29	1931	2	240 AF		[illegible]
D 555		Hamlin Canal	4	1	1891	1	0.01	70	1
D 552		Dunn Canal	6	1	1890	1	0.36	70	1
Squaw Creek, West Branch									
A 627		Thomas Ditch	7	23	1901	1	0.5	70	1
Staudenmaier Reservoir									
A 4764		Staudenmaier Canals 1-2	10	7	1949	5	0		1
Summers Reservoir									
A 4859		Nolan Canals 1-2	6	12	1950	5	0		2
A 4859	D-957	Nolan Canals 1-2	6	12	1950	6	0		2

Application	Annotation		Carrier	Priority Date			Use [1]	Grant [2]	Rate [3]	S
Trout Reservoir										
A 4860		D-959	Trout Canals 1-2	6	12	1950	6	0		2
A 4860			Trout Canals 1-2	6	12	1950	5	0		2
Trunk Butte Creek										
A 8678	B	P-492	Pump	7	19	1956	1	1.19	70	3
A 8678	A	P-492	Pump	7	19	1956	1	1.39	70	3
A 10068			Pump	5	29	1962	1	0.4	70	2
Trunk Butte Creek, Trib. To										
A 9013			White Reservoir No. 1	12	3	1956	2	8 AF		3
Turner Reservoir										
A 1676		D-537	Turner Canal	7	3	1922	6	0		2
A 1677			Turner Canal	7	3	1922	5	0		2
Vyzourek Reservoir No. 2										
A 3457			Emil Canal	10	7	1940	5	0		2
Vyzourek Reservoir No. 3										
A 3458			Vyzourek Canal	12	6	1940	5	0		2
Wallace Reservoir										
A 4036			Wallace Canal	9	16	1946	5	0		2
Wallace Reservoir No. 2										
A 5117			Hay Creek Pump Canals 1-4	8	18	1949	5	0		1
Warbonnet Creek										
D 548			Warbonnet Canal	7	31	1880	1	3.63	70	2
A 892			Warbonnet Canal No. 2	3	11	1908	1	1.5	70	2
D 959			Nolan Canal No. 2	5	1	1888	1	0.29	70	2
D 957	R	P-301	Nolan Canal No. 1	3	15	1887	1	0.01	70	2
Warbonnet Creek, Trib. To										
A 4697			Summers Reservoir	6	12	1950	2	4 AF		2
A 4698			Trout Reservoir	6	12	1950	2	8 AF		2
Wasserburger Reservoir										
A 3581			Wasserburger Canal	5	6	1940	5	0		2
A 3581		A-581	Wasserburger Canal	5	6	1940	6	0		2
Wasserburger Reservoir No. 1										
A 9501		A-2032	Wasserburger Canal	5	9	1955	6	0		2
White Clay Creek										
D 477	R	P-494	White River Canal	12	31	1894	1	1	70	3
A 2063			Mcdowell Reservoir	1	22	1929	2	23.9 AF		
A 42	R	P-408	Pump	6	22	1895	1	0.83	100	3
A 42	R	P-128	Pump	6	22	1895	1	0.05	100	

Application	Annotation	Carrier	Priority Date			Use [1]	Grant [2]	Rate [3]	S
A 42		Cooper Canal	6	22	1895	1	0.66	100	
A 16478		Pump	3	20	1986	4	0.03	70	1
D 475		Hazelton Canal	5	15	1894	1	0.87	70	1
A 9979		Dodd Reservoir	9	31	1961	2	86.5 AF		3
D 960		Mcfarland Canal	5	18	1891	1	1.64	70	3
A 17159		Pump	3	5	1992	1	0.11	70	2
A 9947		Pump	6	30	1961	1	1.14	70	2
A 15513		Pump	7	5	1979	1	0.91	70	3
A 9943		Pumps	6	7	1961	1	1.47	70	2
A 9238	T-710	Pump	2	21	1957	1	2.4	103	
A 8896		Pump	10	11	1956	1	1.19	70	2
A 8999		Pump	11	26	1956	1	0.68	70	2
A 2369		Pump	3	26	1934	1	0.19	70	3
A 4912		Pump	9	24	1951	1	1.63	70	
A 5551		Pump	9	8	1953	1	1.5	70	3
A 16371		Pump	4	4	1985	1	0	70	3
A 4813		Pump	2	28	1951	1	1.16	70	3
White River									
A 1626		Whitney Pipe Line	11	18	1921	1	2.07	70	2
A 5115		Pump	12	18	1952	1	0.44	70	
A 3129		Cistern	4	2	1940	2	0.16 AF		1
A 4835		Pump	4	2	1951	1	0.62	70	1
A 4720		Pump	7	7	1950	1	2.14	70	1
A 10033		Pump	3	20	1962	1	0.76	70	1
A 3038		Pump	12	7	1939	1	0.64	70	3
A 456		Rasher Canal	5	23	1898	1	0.5	70	1
A 2046		Hageman Canal	10	18	1928	1	1.14	70	2
A 4420	A R P-462	Pump	1	11	1949	1	0.54	70	2
A 2627		Whitney Water Supply	8	28	1936	4	2		
A 1604		Whitney Pipe Line	5	2	1921	1	3.21	70	2
A 15885		Pump	6	8	1981	1	1.06	70	
A 15593		Pump	10	23	1979	1	1.55	70	
A 10193		Rasher Canal	5	23	1963	1	0.03	70	1
A 534		Rasher Canal	1	16	1900	1	1.43	70	1
A 5517		Pump	8	28	1953	1	3.61	70	2
A 815		Schwabe Canal	3	19	1906	1	0.26	70	2
A 4021		Pump	1	10	1947	1	0.04	70	
A 12949		Pump	10	1	1973	1	0.05	70	1

Application	Annotation			Carrier	Priority Date			Use[1]	Grant[2]	Rate[3]	S
A 15902				Pump	6	25	1981	1	3	70	
A 15892				Pump	6	15	1981	1	1.67	70	
A 9498				Pumps	5	15	1957	1	1.22	70	1
A 4805				Pumps	2	23	1951	1	1.19	70	
A 15887				Pump	6	10	1981	1	1.85	70	1
A 6247				Pump	4	28	1954	1	4.93	70	2
A 15333				Pump	8	29	1978	1	2.42	70	3
A 3030				Pump	11	24	1939	1	1.31	70	2
A 4983				Pump	6	30	1952	1	2.09	70	2
A 4420	D	R	P-462	Pump	1	11	1949	1	0.73	70	2
A 4420	C	R	0-462	Pump	1	11	1949	1	0.81	70	2
A 4420	B	R	P-462	Pump	1	11	1949	1	1.31	70	2
A 16051			A-1625	Pump	1	18	1982	1	0.91	70	
A 2285				Bartlett Canal	9	8	1932	1	0.3	70	1
A 15484				Pump	5	31	1979	1	0.07	70	3
D 464	B			Harris-Cooper Canal	6	15	1894	1	1.57	70	2
A 2075		R	T-599	Pump	3	12	1929	1	0.37	70	1
D 464	A			Harris-Cooper Canal	3	9	1894	1	10.4	70	2
D 467				Rasher Canal	6	20	1894	1	0.98	70	1
A 8499				Pump	4	20	1956	1	1.1	70	
A 17064			P-473	Golf Course Pond	4	5	1991	2	210 AF		1
A 10193		R	P-440	Harris-Cooper Canal	5	23	1963	1	0.08		2
D 478	C	R	P-279	Hall Pump	1	10	1895	1	0.73	70	2
D 467		R	P-441	Harris-Cooper Canal	6	20	1894	1	0.16		2
A 1128				Rasher-Forbes Canal	9	26	1911	1	0.5	70	1
A 16599				Pump	10	29	1987	3	0.02		3
A 15895			A-4864	Souther Reservoir	6	16	1981	8	41 AF		3
A 15828				White River Canal	4	6	1981	1	3.45	70	3
A 936				White River Canal	3	11	1909	1	1.43	70	3
D 477			T-508	White River Canal	12	31	1894	1	4.28	70	3
A 2381				Pump	5	10	1934	1	0.05	70	
A 15041				Pump	7	25	1977	1	0.07	70	2
D 477	A	R	P-489	Pump	12	31	1894	1	0.21	70	2
A 2609			A-2608	Baldwin Reservoir	8	11	1936	8	332 AF		2
A 1660				Whitney Pipe Line	4	26	1922	1	0.41	70	2
A 9561				Pump	9	6	1957	1	0.64	70	3
A 1603				Whitney Reservoir	4	28	1921	2	E+04 AF		2
A 13602				Harris-Cooper Canal	5	28	1975	1	2.52	70	2

Application	Annotation	Carrier	Priority Date			Use[1]	Grant[2]	Rate[3]	S
A 4740		Pump	8	21	1950	1	0.3	70	2
A 11403		Pump	4	23	1968	1	0.1	70	3
D 1026	R P-512	Crawford Pumps	10	1	1890	4	1.5		
A 15440	R P-442	Harris-Cooper Canal	3	26	1979	1	0.17		2
A 14989		Harris-Cooper Canal	6	21	1977	1	0.86	70	2
A 14480		Harris-Cooper Canal	9	27	1976	1	0.23	70	2
A 1625		Whitney Pipe Line	11	7	1921	1	25	70	2
White River, Trib. To									
A 8266		Pump	11	29	1955	1	0.39	70	2
A 16489		Don Littrel Reservoir	5	14	1986	2	45.3 AF		2
A 9793		Fox Reservoir	2	11	1960	2	21 AF		1
A 3889		Wright Reservoir	4	8	1946	2	18 AF		1
A 10047		Jones Reservoir	4	24	1962	2	29.1 AF		3
A 10099		Betson Canal	9	4	1962	1	0.27	70	[illegible]
A 10048		Jones Canal	4	24	1962	1	1.14	70	3
A 9880		Morris Reservoir	1	17	1961	2	65 AF		2
Whitehead Creek									
A 3414		Geiser Canal	3	13	1941	1	1.24	70	[illegible]
A 9644		Semroska Canal	9	8	1958	1	1.39	70	1
Whitehead Creek, Trib. To									
D 547		Harrison Canal	5	30	1888	1	0.06	70	1
A 4569		Raben Reservoir No. 2	1	13	1950	2	99 AF		2
A 3553		Raben Reservoir No. 1	2	19	1942	2	15 AF		2
Whitney Reservoir									
A 1787	A-1625	Whitney Pipe Line	4	28	1921	6	0		[illegible]
Wickersham Reservoir									
A 2203		Wickersham Canal	12	24	1930	5	0		3
Wiedenfeld Reservoir No. 1									
A 5193		Wiedenfeld Canals 1-2	1	2	1952	5	0		2
Willow Creek									
A 4917		Dunlap Reservoir	11	5	1951	2	16 AF		1
Zimmerman Reservoir									
A 4867		Zimmerman Canal No. 3	11	9	1950	5	0		2

Application	Annotation	Carrier	Priority Date	Use [1]	Grant [2]	Rate [3] S

1 - Uses:

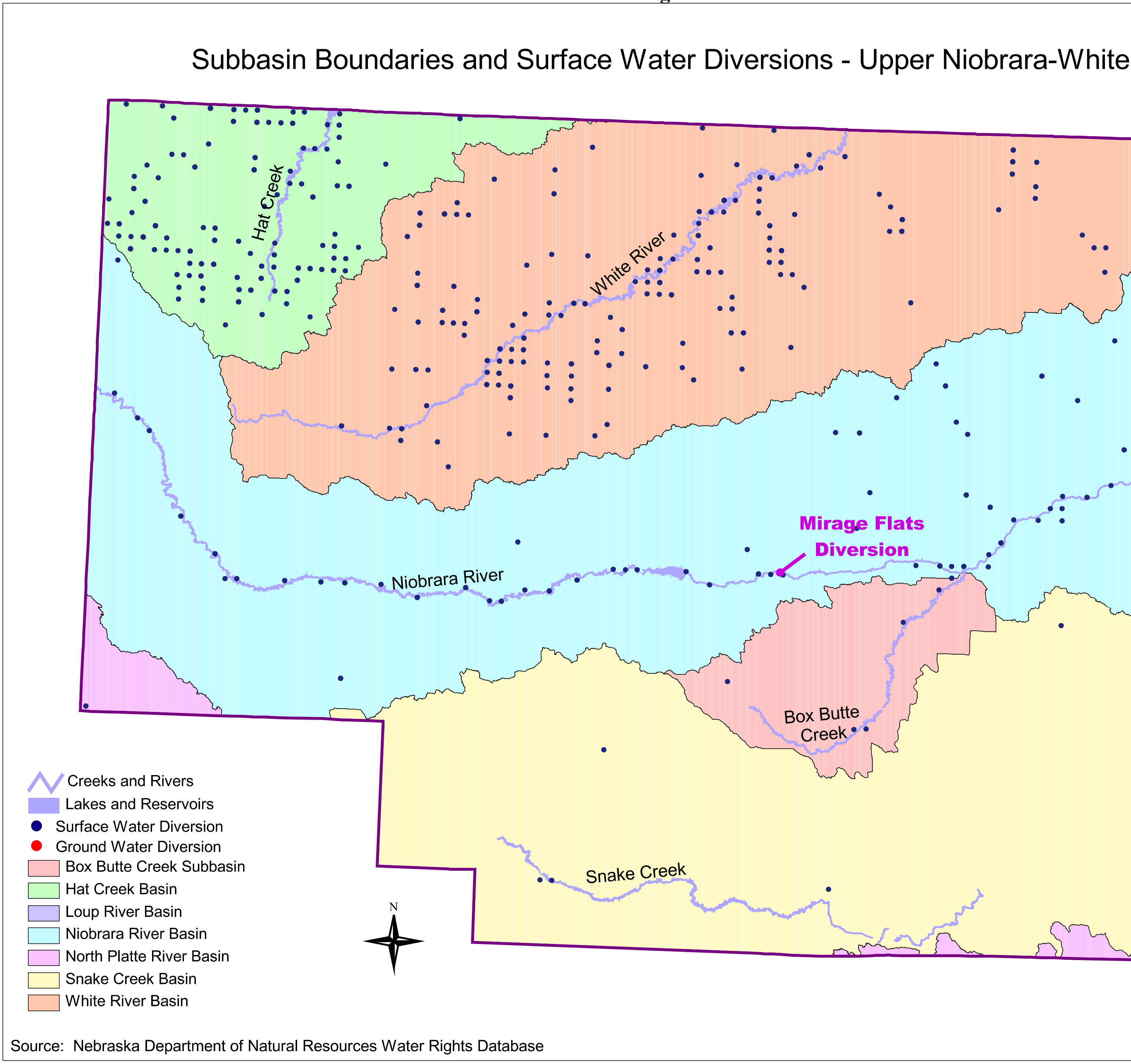
1Irrigation from natural stream
2Storage
3Manufacturing
4Domestic
5Stor-only (irrigation from reservoir on lands not covered by natural flow approriation)
6Supplemental Irrigation (irrig. from reservoir on lands also covered by Natural flow appr.)
7Fish Culture
8Supplemental Storage (An appropriation that has a prior appropriation for storage)
9irrigation and storage (An appropriation which was approoved for both uses)
10Supplemental power and incidental underground water storage
11Power
...
19Incidental underground storage
20Storage and incidental underground storage
21Irrigation and incidental underground storoage
22Supplemental irrigation and incidental underground storage
23Fish and wildlife

2 - Grant: The grant is listed in cubic designated as acre-feet (af).

3 - Rate: The rate refers to the rate at to withdraw water from a stream. Di limited by statute to a maximum of on every 70 acres of land.

Appendix II

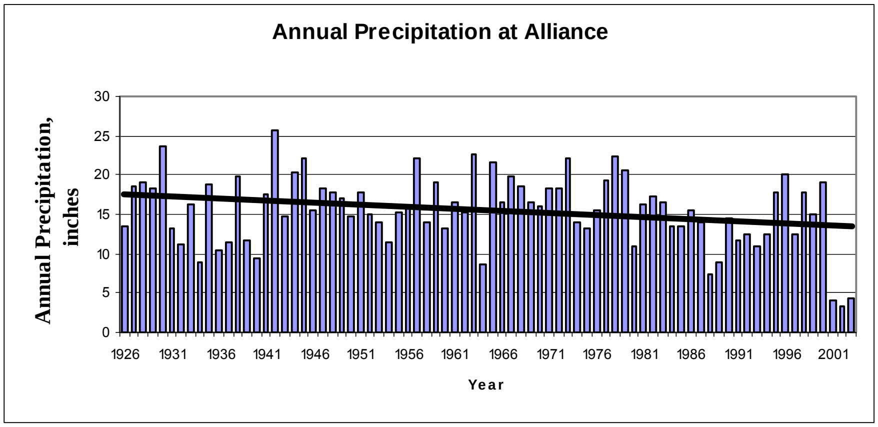
Figure 1

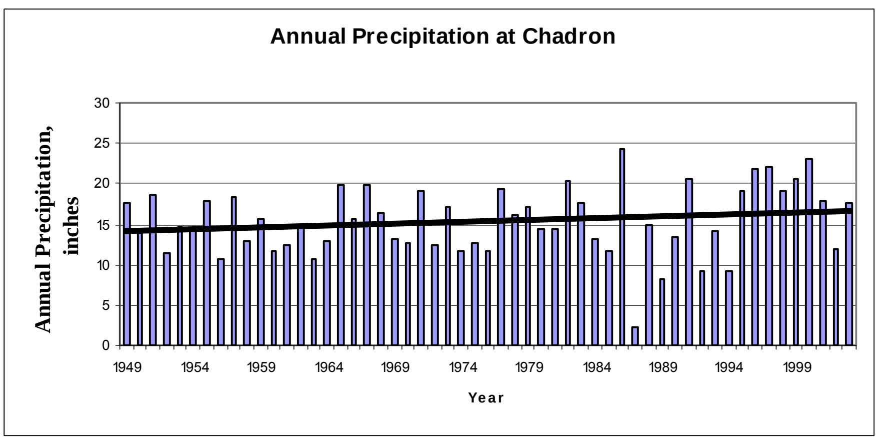


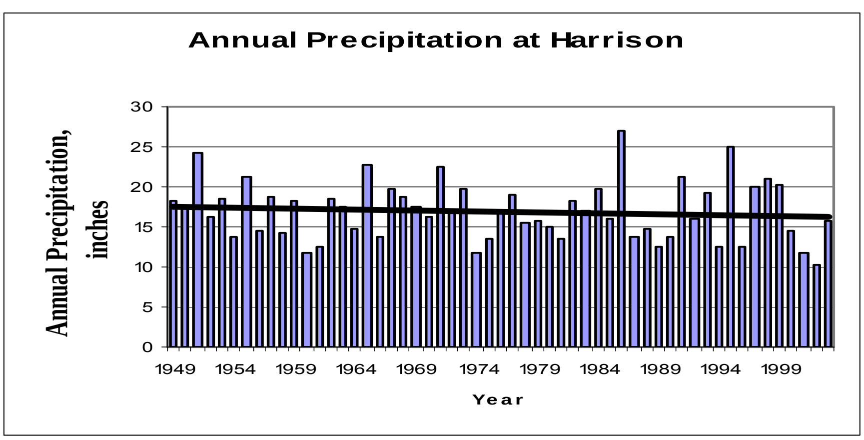
Subbasin Boundaries and Surface Water Diversions - Upper Niobrara-White
Hat Creek
White River
Niobrara River
Mirage Flats
Diversion
Box Butte
Creek
Snake Creek
Creeks and Rivers
Lakes and Reservoirs
Surface Water Diversion
Ground Water Diversion
Box Butte Creek Subbasin
Hat Creek Basin
Loup River Basin
Niobrara River Basin
North Platte River Basin
Snake Creek Basin
White River Basin
N
Source: Nebraska Department of Natural Resources Water Rights Database

Figure 2

Annual Precipitation at Alliance, Chadron, and Harrison By Year



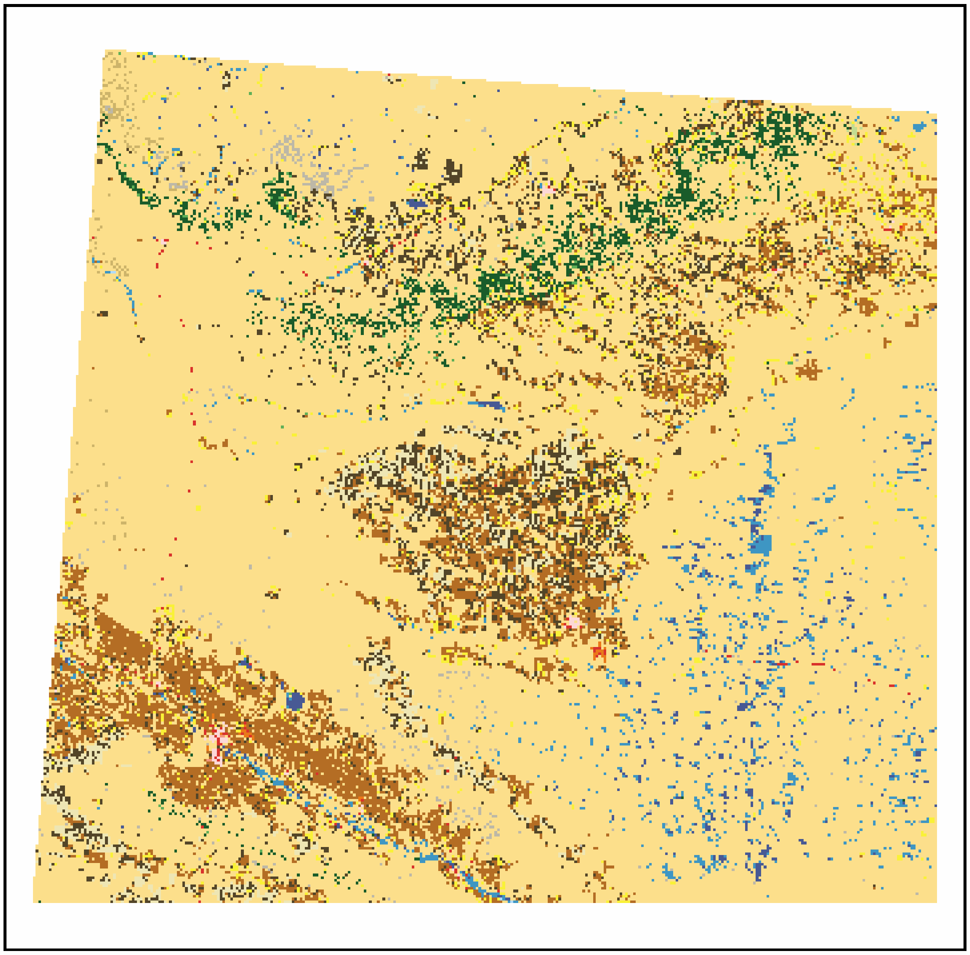




Source: High Plains Regional Climatic Center, University of Nebraska-Lincoln, Lincoln, NE.

Figure 3

National Land Cover Dataset
Northwest Nebraska



National Land Cover Dataset Classification System Legend

Color Key	RGB Value	Class Number and Name
	102, 140, 190	11 - Open Water
	255,255,255	12 - Perennial Ice/Snow
	253, 229, 228	21 - Low Intensity Residential
	247, 178, 159	22 - High Intensity Residential
	231, 86, 78	23 - Commerical/Industrial/Transporta
	210, 205, 192	31 - Bare Rock/Sand/Clay
	175, 175, 177	32 - Quarries/Strip Mines, Gravel Pits
	83, 62, 118	33 - Transitional
	134, 200, 127	41 - Deciduous Forest
	26, 129, 78	42 - Evergreen Forest
	212, 231, 177	43 - Mixed Forest
	220, 202, 143	51 - Shrubland
	187, 174, 118	61 - Orchards/Vineyards
	253, 233, 170	71 - Grasslands/Herbaceous
	252, 246, 93	81 - Pasture/Hay
	202, 145, 71	82 - Row Crops
	121, 108, 75	83 - Small Grains
	244, 238, 203	84 - Fallow
	240, 156, 054	85 - Urban/Recreational Grasses
	201, 230, 249	91 - Woody Wetlands
	144, 192, 217	92 - Emergent Herbaceous Wetlan

Source:
U.S. Geological Survey (USGS) and U.S. Environmental Protection Agency (USEPA)
1992 Landsat TM Data

Figure 4

Cropland Acres and Irrigated Acres in Upper Niobrara-White NRD General Area* — 1969 to 1997

	1969	1978	1987	1992	1997
Total Cropland	1,020215	971,857	1,038,654	1,028,134	1,017,896
Total Irrigated Cropland	102,584	184,071	234,666	237,707	250,078
Harvested Cropland	585,432	597,817	611,303	553,666	616,980
Harvested Irrigated Cropland	96,125	169,771	215,524	229,488	242,379

Corn for Grain and Wheat Production
Upper Niobrara-White NRD, 1969 and 1997

	1969		1997	
	Corn for Grain or Seed (Bushels)	Wheat for Grain (Bushels)	Corn for Grain (Bushels)	Wheat for Grain (Bushels)
Box Butte County	576,634	1,309,251	6,520,983	3,781,151
Dawes County	26,110	611,026	557,436	1,315,099
Sheridan County	324,356	576,569	3,455,817	1,844,016
Sioux County	272,187	65,117	1,930,956	270,842
TOTALS	1,199,287	2,561,963	12,465,192	7,211,108

Source: U.S. Department of Commerce, Bureau of the Census, Census of Agriculture, various years.

*A small portion of Sioux County is actually outside the Upper Niobrara-White NRD boundary. However, for purposes of this table the entire county is included