

Elkhorn River Basin

The Elkhorn River is located in northeast and north-central Nebraska and flows in a southeasterly direction until its confluence with the Platte River near Gretna, Figure E-1. Major tributaries to the Elkhorn River include the South and North Forks of the Elkhorn River, and Logan and Maple Creeks, Figure E-2. The total area of the Elkhorn River Basin (Basin) is approximately 7,000 square miles and includes all of Cuming, Stanton, and Wayne counties and portions of Antelope, Boone, Brown, Burt, Cedar, Colfax, Dakota, Dixon, Dodge, Douglas, Garfield, Holt, Knox, Madison, Pierce, Platte, Rock, Sarpy, Thurston, Washington, and Wheeler counties. County seats in the Basin include Basset, Fremont, Madison, Neligh, O’Neill, Pender, Pierce, Stanton, Wayne, and West Point.

Sources of Water

Precipitation

Annual and growing season (May 1 through September 30) precipitation charts for gage sites in Newport, Norfolk, O’Neill, Wayne and West Point are shown on Figures E-3 through E-12. The average annual precipitation ranges from 23.4 inches at O’Neill in the northwestern portion of the Basin to 29.9 inches at Fremont in the southeastern corner of the Basin. The average growing season precipitation ranges from 11.9 inches at O’Neill to 15.2 inches at Fremont. Locations of the precipitation gages can be seen in Figure E-13.

Ground Water

The hydrogeology of the Basin is complex due to the wide range of depositional environments from eolian in the west to glacial in the east. Nearly 40 percent of the Basin has been glaciated, Figure E-14. For purposes of this report, all saturated unconsolidated sediments of Quaternary age above bedrock inclusive of the paleovalley

alluvial aquifers with hydrologic connection, the alluvial and the shallow aquifers, and the bedrock Tertiary Ogallala Group are combined into the principal aquifer unit for the Basin. Secondary aquifers are made up of the remaining bedrock aquifers. Tables E-1 and E-2 list the aquifers by age with the important hydrogeologic characteristics. The bedrock aquifers range in age from Tertiary to Cretaceous, Figure E-15. The bedrock aquifers supply a small amount of water compared to the other aquifers but are an important source locally (CSD, 2005). They generally are not in hydrologic connection with the streams in the Basin.

The principal aquifer varies in saturated thickness from 0 to approximately 800 feet, Figure E-16. Depth to water from the land surface varies from 0 to more than 200 feet, Figure E-17 (CSD 2005). Transmissivity values range from less than 20,000 gallons per day per foot (gal/day/ft) to more than 250,000 gal/day/ft. Most areas of the eastern part of the Basin have transmissivity values of less than 20,000 gal/day/ft, Figure E-18. Areas of higher transmissivity are generally related to the paleovalley alluvial aquifers or in the western half of the Basin where the Tertiary Ogallala Group makes up a large part of the principal aquifer. Specific yield ranges from less than 5 to greater than 20 percent, Figure E-19. The western and central parts of the Basin exclusive of the glaciated area are in hydrologic connection with the stream and are unconfined in nature. The eastern part of the Basin is complicated due to its glaciated nature and the principal aquifer does not always have hydrologic connection with the streams (with the exception of the alluvial aquifers) (CSD 2005). The ground water table, Figure E-20, reflects a normal gaining stream pattern in the west and central areas and the complicated nature of the glaciated area in the east. Ground water tends to move from the uplands to the streams; however, the ground water contour map should not be taken as an expression of hydrologic connection in the glaciated area (CSD 2005).

Ground Water Use

Ground water in the Basin is used for a variety of purposes: domestic, industrial, livestock, irrigation, and others. There are 12,441 registered ground water wells within

the Basin as of October 1, 2005 (Department registered ground water wells database). Not all wells are registered in the Department database, especially stock and domestic wells, which if drilled prior to 1993 are not required to be registered. Certain dewatering and other temporary wells are not required to be registered. Irrigation is the largest consumer of ground water, with approximately 1,100,000 acres being supplied with water from approximately 8,400 wells as of October 1, 2005 (Department registered ground water wells database).

Ground water development is limited within the Basin by the geology of the area. Figure E-21 illustrates the location of depletive ground water wells. The areal extent of those wells indicates where ground water has been beneficially developed. In the east end of the Basin, wells are mostly found in the paleovalleys and alluvial aquifers. The central section of the Basin shows the broad extent of the principal aquifer and irrigation suitability of the overlying lands. The western end of the Basin lies over the principal aquifer, but development is limited to lands suitable to irrigation. Ground water development analyzed by comparison of completion dates has shown that development of high capacity wells (depletive wells capable of pumping more than 50 gallons per minute) has been steadily increasing with accelerated increases during the years 1967 through 1983 and 1994 to the present, Figures E-22, E-23, and E-24. Table E-3 shows the estimated average irrigated acreage by county within the Basin between 1950 and 2003. The increase in the number of other depletive wells seen in Figures E-23 and E-24 after 1993 is attributed to revision of the well registration statute in 1993.

Changes in Ground Water Table Elevation

Figure E-25 is a map made from a compilation of all ground water elevations reported to the Conservation and Survey Division of the University of Nebraska-Lincoln in cooperation with the U.S. Geological Survey and the Natural Resources Districts. It shows a small area in northern Holt County with a decline of up to 20 feet in ground water table elevations from predevelopment through the spring of 2005. This area is adjacent to a similar area of decline in the Niobrara River Basin. Additional areas of

declines include parts of central Burt, northern Pierce, central Stanton, northwest Cuming and north-central Colfax counties. There is a large area of ground water table elevation increase in southwest Madison County. Figure E-26 is the location map for selected ground water hydrographs across the Basin. Figures E-27 through E-33 are hydrographs (USGS 2005) which give a representative change in ground water table elevations for the particular area. Where possible a graph of a continuous recorder site is used.

Ground Water Management

The Basin primarily encompasses portions of two Natural Resources Districts (NRDs): the Upper Elkhorn NRD (UENRD) and the Lower Elkhorn NRD (LENRD).

The UENRD and the LENRD have each established a ground water management area (GWMA) for quality purposes. As part of the GWMA requirements in each of these NRDs, permits are required prior to the construction of wells pumping greater than 50 gallons per minute (gpm).

Surface Water

Hydrographs from fourteen surface water gages in the Basin are included in this report, Figures E-34 through E-47. They are South Fork of the Elkhorn River at Ewing, Willow Creek near Foster, North Fork of the Elkhorn River near Pierce, Union Creek at Madison, Pebble Creek at Scribner, Maple Creek near Nickerson, Logan Creek at Pender, Logan Creek near Uehling, Elkhorn River near Atkinson, Elkhorn River at Ewing, Elkhorn River at Neligh, Elkhorn River at Norfolk, Elkhorn River at West Point, and Elkhorn River at Waterloo, Figure E-48. Streamflow in the Basin is driven by ground water discharge as baseflow to the streams and by precipitation.

Surface Water Use

As of October 1, 2005, there are approximately 550 surface water appropriations in the Basin issued for a variety of uses. The majority of the surface water appropriations are for irrigation and they tend to be located on the major streams. There are no instream flow appropriations in the Basin, but the instream flow appropriations on the Platte River below its confluence with the Elkhorn River have a major impact on administration in the Basin. The first surface water appropriations in the Basin were permitted in the 1890's and development has continued through present day. The largest period of development occurred between 1974 and 1977, Figure E-49 and Figure E-50. Figure E-51 shows the approximate locations of permitted surface water diversions in the Basin. Information on specific surface water appropriations is available in the Department's biennial report. Information on categories of use can be found in Appendix H.

Analyses for the Fully Appropriated Determination

Surface Water Administration

In the 115-year period since the first surface water appropriation was perfected in the Basin, there have only been a few recorded instances of surface water administration in the administrative record, with the first occurring after 1970. The amount of surface water administration in the Basin has increased significantly since 1998, when the instream flow appropriations were granted. Table E-4 shows the occurrences of water administration between 1985 and 2004. The junior surface water appropriations in the Basin had an average of 53.0 days in which surface water was available for diversion from July 1 through August 31 and 137 days in which surface water was available for diversion from May 1 through September 30.

Table E-4. Water Administration in the Elkhorn River Basin between 1985 and 2004.

Year	Water Body	Days	Closing Date	Opening Date
1990	Willow Creek	14	Aug 17	Aug 31
1991	Taylor Creek	4	Jul 30	Aug 3
1991	Taylor Creek	3	Aug 23	Aug 26
1991	Taylor Creek	7	Aug 28	Sep 4
1991	Union Creek	7	Aug 28	Sep 4
2000	Elkhorn Basin	53	Aug 8	Sep 30
2001	Elkhorn Basin	11	Aug 7	Aug 18
2002	Elkhorn Basin	6	Jun 6	Jun 12
2002	Elkhorn Basin	59	Jun 25	Aug 23
2002	Elkhorn Basin	4	Aug 27	Aug 31
2002	Elkhorn Basin	24	Sep 6	Sep 30
2003	Elkhorn Basin	66	Jul 14	Sep 18
2004	Elkhorn Basin	13	May 6	May 19
2004	Elkhorn Basin	7	Jun 29	Jul 6
2004	Elkhorn Basin	58	Jul 27	Sep 23

There is a senior surface water appropriation that has caused administration in the Basin has a priority date year of 1993, therefore it is necessary to reconstruct the water administration table pursuant to the methodology in Appendix D, Table E-5. Pursuant to the reconstructed table, there were an average of 39.2 days in which surface water was available for diversion from July 1 through August 31 and 115.4 days in which surface water was available for diversion from May 1 through September 30.

Table E-5. Reconstructed Water Administration Table, Elkhorn River Basin, 1985 - 2004

Year	July 1 though August 31 Number of Days Available for Surface Water Diversion	May 1 through September 30 Number of Days Available for Surface Water Diversion
1985	49	135
1986	62	153
1987	48	139
1988	10	69
1989	15	49
1990	18	79
1991	10	71
1992	62	153
1993	62	153
1994	59	149
1995	53	144
1996	62	153
1997	43	134
1998	62	153
1999	62	153
2000	35	97
2001	34	118
2002	5	51
2003	11	77
2004	22	78
Average	39.2	115.4

Determination of Hydrologically Connected Area

No sufficient numeric ground water model is available in the Elkhorn River Basin to determine the 10/50 area or the lag impact of ground water wells.

The 10/50 area was determined using the Jenkins methodology as explained in Appendix D. Figure E-52 shows the extent of the area considered to be hydrologically connected in accordance with Department rule 457 NAC 24.001.02 (Appendix A).

Lag Impacts

a) Current Well Development

The lag impact was computed using the Jenkins methodology documented in Appendix D. The results show that an additional 40 cubic feet per second (cfs) of daily depletion can be expected from the Basin due to the effect of lag impact from existing wells. The total calculated future depletion at Louisville includes the future depletion from the Loup River Basin (see Loup River Basin Chapter), Elkhorn River Basin, and the Platte River (see Lower Platte River Basin Chapter). The sum of those depletions results in a total depletion in the year 2030 of 310 cfs daily if there is no well development.

The results found by comparing the senior surface water appropriation with the depleted daily flows (see methodology in Appendix D) show that in the future the average annual number of days in which surface water will be available for diversion to the junior surface water appropriations in the Basin will be 36.8 days from July 1 through August 31 and 111.9 days from May 1 through September 30 (Table E-6).

Table E-6. Water Administration Table with Current Ground Water Depletions, Elkhorn River Basin, 2011-2030

Year	July 1 though August 31 Number of Days Available for Surface Water Diversion	May 1 through September 30 Number of Days Available for Surface Water Diversion
2011	44	130
2012	59	150
2013	43	134
2014	6	64
2015	14	47
2016	16	77
2017	7	68
2018	61	151
2019	62	153
2020	54	143
2021	53	143
2022	62	153
2023	42	133
2024	62	151
2025	62	153
2026	31	92
2027	27	105
2028	4	47
2029	9	75
2030	17	68
Average	36.8	111.9

b) Future Well Development

Estimates of the number of high capacity wells that would be completed over the next 25 years if no new legal constraints were imposed on the construction of such wells were calculated based on extrapolating the present day rate of increase in well development into the future, Figure E-53. For the past 20 years, the rate of increase in high capacity wells is nearly linear at a rate of 129 wells per year.

The lag impact was computed for the projected wells using the Jenkins methodology documented in Appendix D. The results show that an additional 95 cfs of daily depletion

due to ground water pumping can be expected from the Basin if there is new well development.

The result of the future development depletions can be quantified the same way as with the current depletions. The sum of the depletions with future development results in a total depletion in the year 2030 of 530 cfs daily at Louisville.

The results found by comparing the senior surface water appropriation with the depleted daily flows show that in the future, with no restrictions on well development, the average annual number of days in which surface water will be available for diversion to the junior surface water appropriations in the Basin will be 35.2 days from July 1 through August 31 and 108.5 days from May 1 through September 30, Table E-7.

Table E-7. Water Administration Table with Current and Future Ground Water Depletions, Elkhorn River Basin, 2011-2030

Year	July 1 though August 31 Number of Days Available for Surface Water Diversion	May 1 through September 30 Number of Days Available for Surface Water Diversion
2011	42	126
2012	57	148
2013	40	131
2014	5	60
2015	14	45
2016	13	74
2017	7	67
2018	59	143
2019	62	153
2020	51	138
2021	50	136
2022	61	152
2023	42	133
2024	62	147
2025	62	153
2026	27	88
2027	22	97
2028	4	45
2029	6	71
2030	17	63
Average	35.2	108.5

Future Surface Water Development and Uses

The number of surface water appropriations in the Basin has grown steadily over the past 30 years and it appears reasonable to project that the trend will continue into the future, Figure E-49. The number of acres permitted for surface water irrigation also has grown steadily for the past 30 years, Figure E-50. However, surface water development must be limited to ensure compliance with the Nebraska Nongame and Endangered Species Conservation Act (NNESCA) due to the presence of Pallid Sturgeon and Sturgeon Chub in the Lower Platte River. The Department and the Nebraska Game and Parks Commission have a policy regarding the procedure for issuing new surface water appropriations and amending existing appropriations so that NNESCA will be complied with. This policy limits the number of surface water appropriations that can be issued without further study of the effects on these species.

Ability to Satisfy Net Corn Crop Irrigation Requirement

Figure E-54 shows the net corn crop irrigation requirement for the Basin. The map shows the net corn crop irrigation requirement to range from approximately 11.0 inches in the western portion of the Basin to approximately 6.5 inches at the southeast corner of the Basin. Assuming a surface water diversion rate equal to 1 cubic foot per second per 70 acres and a downtime value of 10 percent; depending on the location in the Basin, it takes between 17.3 and 29.2 days annually to divert 65% of net corn crop irrigation requirement from July 1 through August 31 and 22.6 to 38.2 days to divert 85% of the net corn crop irrigation requirement from May 1 through September 30.

The reconstructed surface water administration analysis showed an average of 39.2 days in which surface water was available for diversion from July 1 through August 31 and an average of at least 115.4 days in which surface water was available for diversion from May 1 through September 30. The number of days in which surface water was available for diversion in both the July 1 through August 31 and the May 1 through September 30 time frames exceeds the number of days surface water is required to be available for the

greatest net corn crop irrigation requirement for the junior surface water appropriations in the Basin during those same periods.

Sufficiency of Surface Water Supply [Nebraska Revised Statutes Section 46-713(3)(a) (Reissue 2004)]

The average number of days in which surface water was available for diversion in both the July 1 through August 31 and the May 1 through September 30 time frames required by Department rule 457 Nebraska Administrative Code (NAC) 24.001.01 exceeds the number of days surface water is required to be available pursuant to the rule during those same periods. The lag impact analyses show that even in the future, the number of days in which surface water will be available for diversion in both time periods will exceed the number of days surface water would be required to be available. Table E-8 summarizes the results of comparisons between the number of days surface water must be available to meet the 65% and 85% net corn crop irrigation requirements and the number of days in which surface water was available for diversion to the junior surface water appropriations.

Table E-8. Summary of Comparison Between Net Corn Crop Irrigation Requirement and Number of Days Surface Water is Available for Diversion.

	Number of Days Necessary to Meet the 65% and 85% of Net Corn Crop Irrigation Requirement	Average Annual Number of Days Available to the Junior Surface Water Appropriations (1985-2004)*	Average Annual Number of Days Available in 2030 with no Additional Well Development	Average Annual Number of Days Available in 2030 with Additional Well Development
July 1 – August 31	29.2	39.2 (10.0 days above the requirement)	36.8 (7.6 days above the requirement)	35.2 (6.0 days above the requirement)
May 1 – September 30	38.2	115.4 (77.2 days above the requirement)	111.9 (73.7 days above the requirement)	109.2 (70.3 days above the requirement)

* From the reconstructed administration record.

Sufficiency of Streamflow for Ground Water Supply [Nebraska Revised Statutes Section 46-713(3)(b) (Reissue 2004)]

Since the criteria for Nebraska Revised Statutes Section 46-713(3)(a) were satisfied, the conclusion for this section is the same for reasons explained in the report introduction.

Sufficiency of Surface Water Supply for Compliance with Compacts or State Laws [Nebraska Revised Statutes Section 46-713(3)(c) (Reissue 2004)]

There are no compacts on any portions of the Elkhorn River Basin in Nebraska. At this time there is sufficient water supply in the Basin to comply with NNECSA and, as discussed above, future development will be limited so as to continue compliance.

Future Development of Surface and Ground Water [Nebraska Revised Statutes Section 42-713(1)(b) (Reissue 2004)]

Given the rate of registered ground water well and surface water appropriation development, the conclusion that the Basin is not fully appropriated would not change even if no additional legal constraints were placed on development and a reasonable projection of a continuation of the current trend of well development of the last 20 years is used.

Conclusions

There is no evidence that current ground water depletions to streamflow in the Basin are affecting surface water users sufficiently to meet the criteria for being fully appropriated as found in Department rule 457 NAC 24.001.01 when compared to the amount of surface water available at the present time.

There is no evidence available at this time that lag impact will be sufficient in 25 years to affect existing water users enough to meet the criteria for being fully appropriated as found in Department rule 457 NAC 24.001.01.

Based upon available information and its evaluation, the Department has reached a determination that the Basin is not fully appropriated. The Department has also determined that even if no additional legal constraints are imposed on future development of hydrologically connected surface water and ground water and reasonable projections are made about the extent and location of future development, this conclusion would not change.