2017

Annual Evaluation of Availability of Hydrologically Connected Water Supplies

Published by the
Nebraska Department of Natural Resources
December 30, 2016

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Report Organization

This report is divided into nine sections. Section One is the report summary. Section Two is the introduction to the report and contains the purpose, background, and organization. The pertinent statutory and regulatory language can be found in Section Three and in Appendix A. Detailed descriptions of the methodologies used in the analyses can be found in Section Four. Sections Five through Eight are the evaluations of the Big Blue River Basins, Lower Niobrara River Basin, Lower Platte River Basin, and Missouri Tributary Basins, respectively. Each basin evaluation includes a description of the nature and extent of present water uses, the geographic area considered to have hydrologically connected groundwater and surface water (i.e., the “10/50 area”), preliminary conclusions about the adequacy of the long-term water supply, and whether the preliminary conclusions would change if no additional constraints were placed on water development in the basin. Section Nine is a summary of the basin subsections and the report conclusions. The appendices contain additional detailed information not found within the main body of the report.

1.0 SUMMARY

The Nebraska Department of Natural Resources (Department) has evaluated the expected long-term availability of surface water supplies and hydrologically connected groundwater supplies of the Blue River Basins, the Lower Niobrara River Basin, the Lower Platte River Basin, and the Missouri Tributary Basins, and has concluded that none of these basins, nor any of the subbasins or reaches within these basins, are fully appropriated at the present time.

Using the best available science and methods, the Department conducted an additional evaluation of the long-term water supplies with no additional constraints on groundwater and surface water development in the Blue River Basins, the Lower Niobrara River Basin, the Lower Platte River Basin, and the Missouri Tributary Basins. The results of this evaluation indicated that the preliminary determination would not change based on reasonable projections of future development in the basins.

The analyses performed for this fully appropriated basin report are reflective of the Department's current rules regarding the evaluation. The current rules assess the availability of water to junior irrigation rights. There are other methods, such as the Department's INSIGHT methodology, that can be used to also assess available water supplies, all major demands, and the balances within basins across the state (http://data.dnr.ne.gov/insight/). The INSIGHT methodology likely provides more valuable data to inform water management decisions and guide planning processes; however the analysis results may vary greatly from the results from the current rule. A basin which is not fully appropriated under the current rule could still see shortages to water supplies when a more comprehensive analysis, such as the INSIGHT methodology, is applied.

2.0 INTRODUCTION

2.1 Purpose

The purpose of this report is to fulfill the requirements of section 46-713 of the Ground Water Management and Protection Act (Act) (*Neb. Rev. Stat*. §§ 46-701 through 46-756). The Act requires the Department to report annually its evaluation of the expected long-term availability of hydrologically connected water supplies. This annual evaluation is required for every river basin, subbasin, or reach that has not previously been determined to be fully or overappropriated, or for which a status change has not occurred within the previous four-year period, pursuant to *Neb. Rev. Stat* § 46-713(1)(a). No re-evaluations were made in this report for basins, subbasins, or reaches that have previously been determined to be fully or overappropriated.

The evaluation and preliminary conclusions of this report are grouped into four river basins: the Blue River Basins, Lower Niobrara River Basin, Lower Platte River Basin, and Missouri Tributary Basins. This format is intended to reduce repetition; each appropriate basin, subbasin, and reach, however, was analyzed separately.

As required by statute, the report describes the nature and extent of present water uses in the basins, shows the geographic areas considered to have hydrologically connected surface water and groundwater supplies, and predicts how the Department's preliminary conclusions might change if no new legal restrictions are placed on water development in the basins. The report does not address the sufficiency of groundwater supplies that are not hydrologically connected to surface water streams. The report includes a description of the criteria and methodologies used to determine whether basins, subbasins, or reaches are preliminarily considered to be fully appropriated and which water supplies are hydrologically connected. The report is required to include a summary of relevant data provided by any interested party concerning the social, economic, and environmental impacts of additional hydrologically connected surface water and groundwater uses on resources that are dependent on streamflow or groundwater levels but that are not protected by appropriations or regulations. Appendix B contains the notice of request for any relevant data from any interested party and all comments received.

2.2 Background

This report addresses requirements that were added to the Act by passage of LB 962 in 2004. That bill was influenced by actions taken as a result of prior legislative activity. In 2002, the Nebraska Unicameral passed LB 1003, mandating the creation of a Water Policy Task Force to address conjunctive use management issues, inequities between surface water and groundwater users, and water transfers/water banking. The 49 Task Force members, appointed by Governor Mike Johanns from a statutorily specified mix of organizations and interests, were asked to discuss issues, identify options for resolution of issues, and make recommendations to the legislature and governor relating to any water policy changes deemed desirable.

In December 2003, the Task Force provided the Legislature with the *Report of the Nebraska Water Policy Task Force to the 2003 Nebraska Legislature*. That report provided draft legislation and suggested changes to statutes. The Legislature considered the Task Force recommendations in its 2004 session and subsequently passed LB 962, which incorporated most of the Task Force's recommendations. Governor Johanns signed the bill into law on April 15, 2004.

The provisions of LB 962 require a proactive approach in anticipating and preventing conflicts between surface water and groundwater users. Where conflicts already exist, LB 962 established principles and timelines for resolving those conflicts. It also added more flexibility to statutes governing transfer of surface water rights to a different location of use and updated a number of individual water management statutes.

Some of the key provisions of LB 962 that are part of current statutes include the following:

- The Department must make an annual determination by January 1, 2006, and by January 1 of each subsequent year, as to which basins, subbasins, or reaches not previously designated as fully appropriated or overappropriated have since become fully appropriated. The Department must specify by rule and regulation the types of scientific criteria and other information to be used in the analysis, complete an annual evaluation of the expected long-term availability of hydrologically connected water supplies in the basins, subbasins, or reaches, and issue a report describing the results of the evaluation.

- When a basin, subbasin, or reach is determined to be fully appropriated, stays on new uses of groundwater and surface water are automatically imposed. The Department and the NRDs involved are required to jointly develop and implement an integrated management plan (IMP) within three to five years of that designation.

- A key goal of each IMP is to manage all hydrologically connected groundwater and surface water for the purpose of sustaining a balance between water uses and water supplies so that the economic viability, social and environmental health, safety, and welfare of the basin, subbasin, or reach can be achieved and maintained for both the near- and long-term. In the overappropriated portions of the state, the IMP must provide for a planned incremental approach toward achieving this goal.

- IMPs may rely on a number of voluntary and regulatory controls, including incentives, allocation of groundwater withdrawals, rotation of use, and reduction of irrigated acres, among others.

- If a dispute between the Department and an NRD over the development or implementation of an IMP cannot be resolved, the governor will appoint a five-member Interrelated Water Review Board to resolve the issue.

Shortly after the passage of LB 962, a number of basins, subbasins, or reaches were determined to be fully or overappropriated. These areas included portions of the Platte River Basin, Republican River Basin, Upper Niobrara River Basin, White River Basin, and Hat Creek Basin (Figures 2-1 and 2-2). Additionally, following the status change of the Lower Platte River Basin preliminary determination in April 2009, the legislature passed LB 483 and LB 54.

Some of the key provisions of LB 483 and LB 54 that are relevant to development of this report include the following:

- The NRDs affected by a status change (i.e., reversal of preliminary determination that a basin, subbasin, or reach is fully appropriated) of a basin, subbasin, or reach must develop rules to limit the total number of new groundwater irrigated acres annually for a period of at least four years following the status change.

- The Department must approve each NRD's proposed number of new irrigated acres if the basin, subbasin, or reach would not be caused to be fully appropriated based on the most recent annual evaluation. Absent such approval, the NRDs must limit new irrigated acres to 2,500 or 20 percent of the historically irrigated acres, whichever is less.

- The Department must ensure that any new appropriation granted will not cause the basin, subbasin, or reach to be fully appropriated based on the most recent annual evaluation.

- The Department must limit new natural flow surface water appropriations for irrigation within the basin, subbasin, or reach to ensure that there is not a net increase of more than 834 irrigated acres in each NRD during each calendar year of the four-year period.

- The Department is not required to perform an annual evaluation for a river basin, subbasin, or reach during the four years following a status change in such river basin, subbasin, or reach.

No areas are currently subject to the restrictions resulting from the passage of LB 483.

Previous statutorily required reports on the evaluation of hydrologically connected water supplies are available online (http://www.dnr.nebraska.gov/iwm/fab-reports) or upon request from the Department.

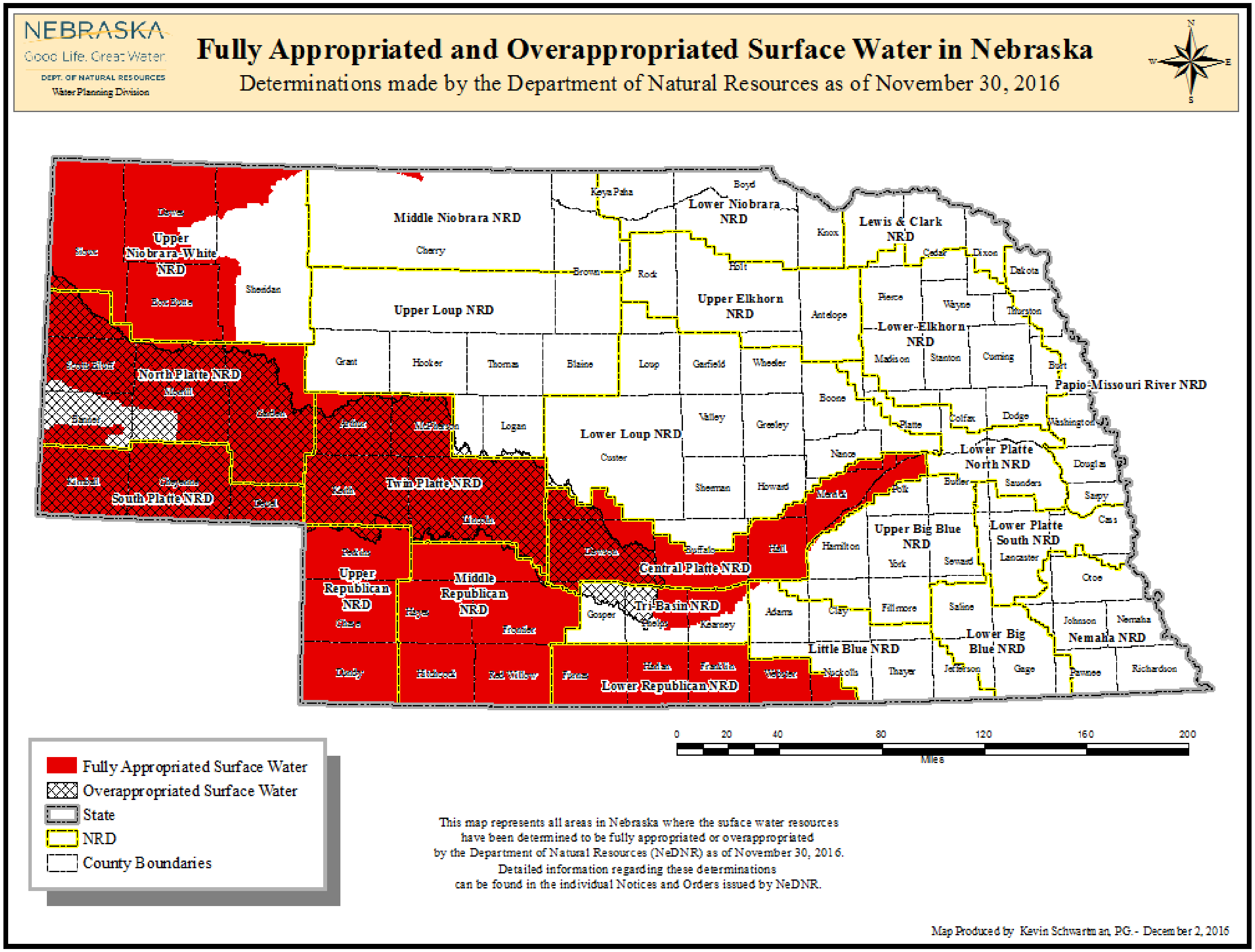


Figure 2-1. Areas designated as fully appropriated or overappropriated basins, subbasins, and reaches since the passage of LB 962.

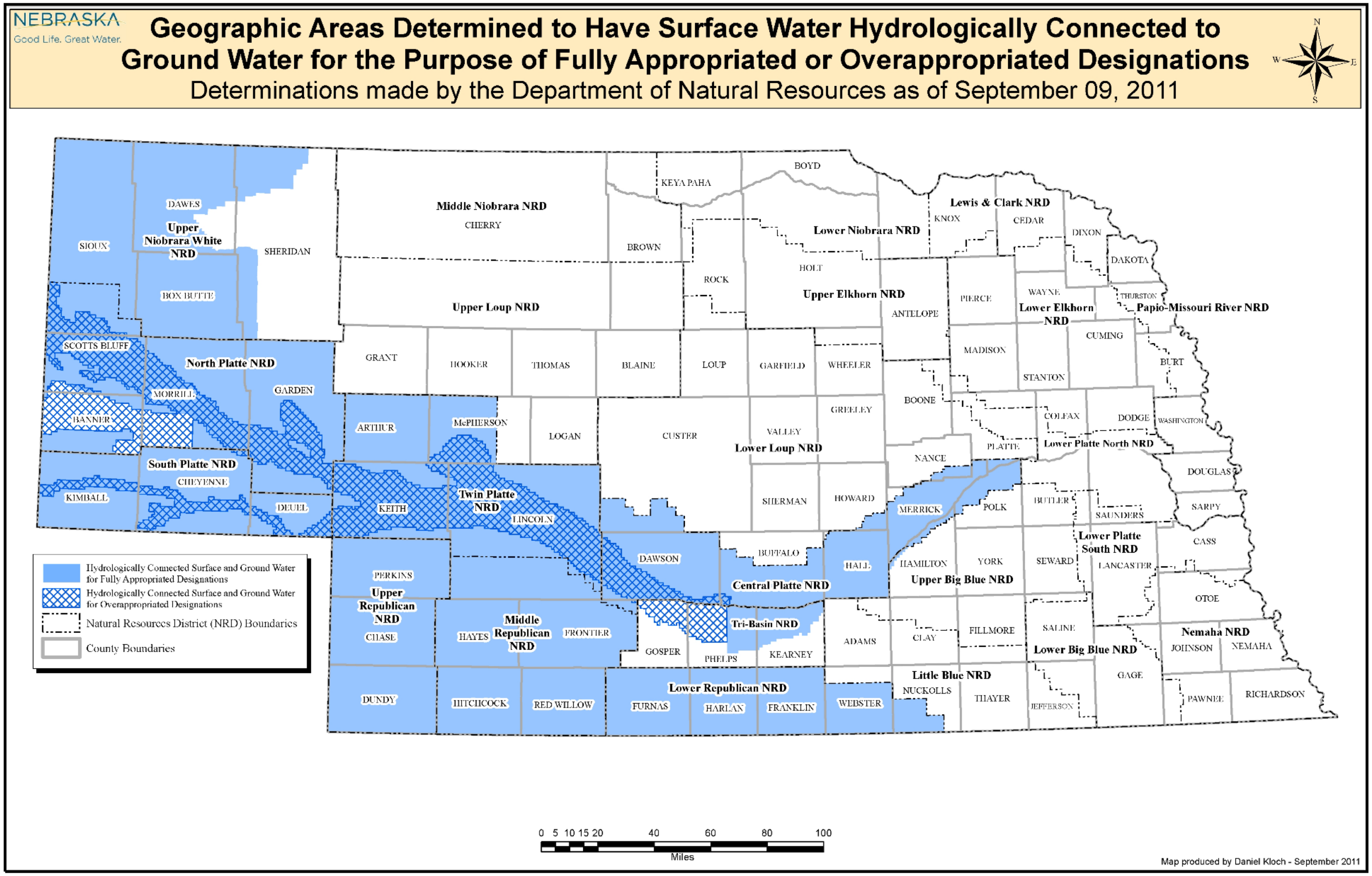


Figure 2-2. Areas designated as hydrologically connected to fully appropriated or overappropriated basins, subbasins, and reaches since the passage of LB 962.

3.0 LEGAL REQUIREMENTS

3.1 Section 46-713(1)(a) – Annual Evaluation and Report Required

A river basin's hydrologically connected water supplies include both the surface water in the watershed or catchment that runs off to the stream and the groundwater that is in hydrologic connection with the stream. For all evaluated basins, the geographic areas of hydrologically connected surface water and groundwater, where present, are illustrated on a basin-wide map that is included in each basin's subsection of the report. On each of those maps, the surface watershed basin is shown by a solid line and the hydrologically connected groundwater portion of the basin is depicted by a shaded area.

Surface water supplies are considered to be hydrologically connected to a stream or stream reach if the surface water drains to that stream or reach. In accordance with Department rule *457 Neb. Admin. Code* Chapter 24, § 001.02, the Department considers the area within which groundwater is hydrologically connected to a stream to be that area in which "pumping of a well for 50 years will deplete a river or baseflow tributary thereof by at least 10 percent of the amount pumped in that time" (i.e., the "10/50 area"). For the purposes of evaluation, a river basin may be divided into two or more subbasins or reaches. All basins are required to be evaluated except those basins that have previously been determined as overappropriated or fully appropriated or that have experienced a status change (i.e., reversal of preliminary determination that a basin, subbasin, or reach is fully appropriated) in the previous four years.

In preparing its annual report, the Department is required by *Neb. Rev. Stat.* § 46-713(1)(d) to rely on the best scientific data, information, and methodologies readily available to ensure that the conclusions and results contained in the report are reliable. A list of the information the Department may use is found in rule *457 Neb. Admin. Code* Chapter 24, § 002 (Appendix A). The Department is also required to provide enough documentation in the report to allow others to independently replicate and assess the Department's data, information, methodologies, and conclusions. That documentation can be found throughout the report. The raw data used for these calculations and the spreadsheets with the calculations can be accessed online (ftp://dnrftp.dnr.ne.gov/Pub/FAB_Report/) or provided by the Department upon request.

3.2 Section 46-713(1)(b) – Preliminary Conclusions Following Basin Evaluations

As a result of its annual evaluation, the Department is to arrive at a preliminary conclusion as to whether or not each river basin, subbasin, and reach evaluated is currently fully appropriated without the initiation of additional uses. The Department is also required to determine if and how its preliminary conclusions would change if no additional legal constraints were imposed on future development of hydrologically connected surface water and groundwater. This determination is based on reasonable projections of the extent and location of future development in a basin.

3.3 Section 46-713(3) – Determination that a Basin is Fully Appropriated

The Department must make a final determination that a basin, subbasin, or reach is fully appropriated if the current uses of hydrologically connected surface and groundwater in the basin, subbasin, or reach cause, or will in the reasonably foreseeable future cause, either (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, (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. Since these factors must be considered in making the final determination, they must also be part of the Department's considerations in reaching its preliminary conclusions.

The Department considered whether or not condition (c) would be met with regard to interstate compacts by reviewing the terms of any compacts in each basin and determining when noncompliance would occur if there were sufficient reductions in streamflow. There were no decrees, formal state contracts, or agreements in any of the basins evaluated this year; there is one interstate compact covering the Blue River Basins.

With regard to noncompliance with state and federal law, it was determined that only the state and federal laws prohibiting the taking of threatened and endangered species could raise compliance issues that would trigger condition (c). The federal Endangered Species Act (ESA), 16 U.S.C. §§ 1530 *et seq.*, prohibits the taking of any federally listed threatened or endangered species of animal by the actual killing or harming of an individual member of the species (16 U.S.C. § 1532) or by the significant modification or degradation of designated critical habitat where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering (50 CFR § 17.3). The state Nongame and Endangered Species Conservation Act (NNESCA), *Neb. Rev. Stat.* §§ 37-801 *et seq.*, also prohibits the actual killing or harming of an individual member of a listed species and the destruction or modification of designated critical habitat. It was concluded that any reductions in flow that may occur as a result of not determining a basin, subbasin, or reach to be fully appropriated will not cause noncompliance with either federal or state law at this time in any of the basins evaluated.

Prior to making a final determination that a basin is fully appropriated, the Department must also hold a public hearing on its preliminary conclusions and consider any testimony and information given at the public hearing or hearings.

4.0 METHODOLOGY

This section provides an overview of the methodologies used in the Department's basin evaluations and is separated into three subsections:

1) The first subsection outlines the legal requirements established in section 46-713 of the Ground Water Management and Protection Act (Act) and regulation *457 Neb. Admin. Code* Chapter 24 (Appendix A) as they relate to the analysis.
2) The second subsection provides the overall procedure for evaluation of each basin.
3) The third subsection discusses the specific methods implemented by the Department to calculate the extent of the hydrologically connected (10/50) area.

4.1 Legal Obligation of the Department

4.1.1 The Legal Requirements of Section 46-713

The methodologies used for evaluation within this report were developed to meet the requirements of section 46-713 of the Act. The criteria set forth in section 46-713 require the Department to: 1) describe the nature and extent of surface and groundwater uses in each river basin, subbasin, or reach; 2) define the geographic area within which surface water and groundwater are hydrologically connected; 3) define the extent to which current uses will affect available near-term and long-term water supplies; and 4) determine how preliminary conclusions based on current development would change if no additional legal constraints were imposed on reasonable projections of future development.

The description of the nature and extent of surface and groundwater uses is based on information obtained through published reports from the Conservation and Survey Division of the University of Nebraska (CSD), the U.S. Geological Survey (USGS), NRDs, Department databases, and other sources as noted in the text. This information represents the most current publications available. These data include information on transmissivity, specific yield, saturated thickness, depth to water, surficial geology, bedrock geology, water table elevation change, and test-hole information. These data are available on the CSD and USGS websites, http://snr.unl.edu/csd/ and http://waterdata.usgs.gov/ne/nwis/nwis, respectively. All data utilized in this report are available online (ftp://dnrftp.dnr.ne.gov/Pub/FAB_Report) or from the Department upon request. These data and the following methodologies are provided to allow for reproducibility of the results.

4.1.2 Regulation *457 Neb. Admin. Code* Chapter 24, § 001

The Department's evaluation of the extent to which current uses will affect available near-term and long-term water supplies considers current surface water appropriations, current well development, and the 25-year lag impacts from current well development on surface water flows. For the purposes of this report, lag impacts are defined as the delayed effect that the consumptive use of water associated with well pumping will have on hydrologically connected streamflow and its associated impact on surface water appropriations.

Regulation *457 Neb. Admin. Code* Chapter 24, § 001 generally states that a basin is fully appropriated if current uses of hydrologically connected surface water and groundwater in a basin cause, or will cause in the reasonably foreseeable future, (a) the surface water to be insufficient to sustain over the long term the beneficial purposes for which the existing surface water appropriations were 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 basin's river or stream, or (c) reduction in streamflow sufficient to cause Nebraska to be in noncompliance with an interstate compact or decree, formal state contract, or state or federal laws.

In short, regulation *457 Neb. Admin. Code* Chapter 24 states that the surface water supply is deemed to be insufficient if, at current levels of development, the most junior irrigation right in a basin, subbasin, or reach has been unable to divert sufficient surface water over the last 20 years to provide 85 percent of the amount of water a corn crop needs (i.e., the net corn crop irrigation requirement, or NCCIR) during the irrigation season (May 1 through September 30), or if the most junior irrigation right in a basin, subbasin, or reach is unable to divert 65 percent of the amount of water a corn crop needs during the key growing period of July 1 through August 31. For the purposes of this report, this is deemed the “65/85 rule.”

If the requirements of the 65/85 rule are not satisfied, then the final step in a preliminary conclusion of whether a basin is fully appropriated is to apply what has been termed the “erosion rule” (*457 Neb. Admin. Code* Chapter 24, § 001.01C). This rule takes into account the fact that appropriations may be granted even though sufficient water is not available at the time they are granted to provide enough water for diversion to satisfy the requirements of the 65/85 rule. If an appropriation is unable to divert enough water to satisfy the requirements of the 65/85 rule, a second evaluation is completed to determine if the right has been “eroded.” According to regulation *457 Neb. Admin. Code* Chapter 24, § 001.01B, in the event that the junior water right is not an irrigation right, the Department will use a standard of interference appropriate for the type of water use to determine whether flows are sufficient for that use, taking into account the purpose for which the appropriation was granted.

The Department is also required to assess how its preliminary conclusions, based on current development, might change by predicting future development. The predictions of future development account for existing wells and wells that may be added in the next 25 years. When projecting the quantity of wells that may be added to the number of currently developed wells, the Department considers the following: 1) the availability of lands suitable for irrigation and 2) recent trends in well development.

4.1.2.1 The Role of the Surface Water Administration Doctrine in Implementation of the 65/85 Rule

The administration of surface water plays a key role in evaluating a basin, subbasin, or reach. Surface water appropriations in Nebraska are administered under the doctrine of prior appropriation. The basis for the doctrine is “first in time, first in right.” When surface water is in short supply in a basin, subbasin, or reach, the surface water appropriation with a senior priority date has the right to use any available water for beneficial use, up to its permitted limit, before any upstream junior surface water appropriation can use water. To exercise a senior right, the senior water appropriation will put a call on the stream; the Department will investigate the streamflows, and, if necessary, issue closing orders to the upstream junior water appropriations, starting with the most junior right.

Although additional surface water development in a basin will deplete the overall surface water supplies during times when excess surface water is available, under the priority system a junior right cannot cause a senior surface water appropriation's supply to be reduced. When the Department administers for a calling senior surface water appropriation, all upstream junior surface water appropriations, starting with the most junior appropriator, are shut off in order of priority, no matter how far upstream, until the calling senior surface water appropriation is satisfied. Therefore, in areas where surface water administration is already occurring, additional surface water development will not reduce the number of days surface water is available for diversion by a senior surface water appropriation. In areas that have not experienced surface water administration, it is currently not feasible to predict the point in time at which additional surface water development may cause surface water administration to occur.

The priority doctrine, which governs surface water administration, ensures that if sufficient water is available for the most junior irrigation appropriation, then all irrigation appropriations will be satisfied. Therefore, in each basin evaluation, the Department analyzed the water available to the most junior appropriator. When making the calculation of the number of days that surface water was available to the most junior irrigation surface water appropriator, the Department assumed that, if the junior appropriator was not closed, then he or she could have diverted at the full permitted diversion rate.

4.1.3 Regulation *457 Neb. Admin. Code* Chapter 24, § 001.02

The Department must determine the geographic area within which surface water and groundwater are hydrologically connected. Regulation *457 Neb. Admin. Code* Chapter 24, § 001.02 states that the geographic area within which the groundwater and surface water are hydrologically connected is determined by calculating where, in each river basin, a well would deplete a river's flow by 10 percent of the amount of water the well could pump over a 50-year period (i.e., "the 10/50 area"). The 10/50 area serves as the minimum area that would be subject to preliminary stays when a basin is determined to be fully appropriated or to restrictions on the development of irrigated acres following a basin status change.

4.1.4 Utilization of the Best Available Science in the Annual Evaluation

The Department must rely on the best scientific data, information, and methodologies readily available to ensure that the conclusions and results arrived at through the annual evaluation are reliable. The Department has specified by rule and regulation the types of scientific data and other information that will be considered in the annual evaluation (*457 Neb. Admin. Code* Chapter 24, § 002). Specific data relied upon by the Department are referenced throughout this report and are cited in the section bibliographies.

A key component of the methods used by the Department in this report is the implementation of methods to assess stream depletions by groundwater wells. There are several methods available for estimating the extent and magnitude of stream depletions. Historically, three broad categories have been used to study groundwater flow systems, including sand tank models, analog models, and mathematical models, which include analytical models and numerical models. The first two methods were primarily used prior to the advent of modern, high-speed, digital computers. Since the advent of computers, analytical and numerical models have become the preferred methods for evaluating stream depletions from groundwater pumping. Limitations of each method must be considered by the user when examining the results of analyses and the appropriateness of each method for a given task. With user-friendly interfaces and high-speed computers, numerical models have become the preferred method of evaluating regional groundwater flow. One widely used numerical model developed by the USGS is MODFLOW (McDonald and Harbaugh 1988). For the purposes of this report, if an acceptable Department peer-reviewed MODFLOW model suitable for regional analysis was available, it was used to assist in analysis.

For this year's report, the Upper Niobrara-White Model was used for establishing the extent of hydrologically connected areas in portions of the Lower Niobrara River Basin; the CEntral NEBraska Model (CENEB) was used for evaluating groundwater depletions and establishing the extent of hydrologically connected areas in portions of the Lower Niobrara River Basin, and the Loup River and Upper Elkhorn River subbasins of the Lower Platte River Basin; and the Blue Basins Model was used for establishing the extent of hydrologically connected areas in the Big Blue River and Little Blue River basins. These models were developed by the Department and build on previous modeling efforts in these basins. The documentation and model runs used in this evaluation are available through the links below:

- Upper Niobrara-White Model Documentation: http://dnr.ne.gov/Media/iwm/Niobrara/UNWreport_Final.pdf
- CENEB Model Documentation: http://dnr.ne.gov/Media/iwm/PDF/20130805_CENEB_ReportFINAL.pdf
- Blue Basins Model Documentation:
- http://www.dnr.ne.gov/Media/iwm/PDF/GroundwaterModel_BlueRiverBasins_2013.pdfUpper Niobrara-White Model, CENEB Model, and Blue Basins Model Runs: ftp://dnrftp.dnr.ne.gov/Pub/FAB_Report

All other areas covered by this report were evaluated using analytical techniques that are described further below.

The analytical Jenkins (1968) method for calculation of stream depletion factors (SDF) (Appendix C) lends itself best to the basin-wide aspect of the task described in this report. This method is based on simplifying assumptions and was built upon previously published equations. For this report, the Jenkins method was used in evaluating streamflow depletions for portions of the Missouri Tributary Basins and portions of the Lower Platte River Basin (those not covered by the CENEB model).

Modified versions of the Jenkins method have been developed to address more complex situations, such as the presence of boundary conditions (Miller and Durnford, 2005) and a streambed (Hunt, 1999 and Zlotnik, 2004). These modified methods require additional data such as streambed conductance. The streambed conductance data was available for the Blue River Basins, and thus the Hunt method was applied in these Basins for calculating groundwater depletions to streamflow.

In some areas of the state, use of the analytical method to determine the 10/50 area or the lag impact of groundwater pumping from wells was not completed. These areas typically lack information regarding the hydrologic connection between streams and aquifers or other necessary information.

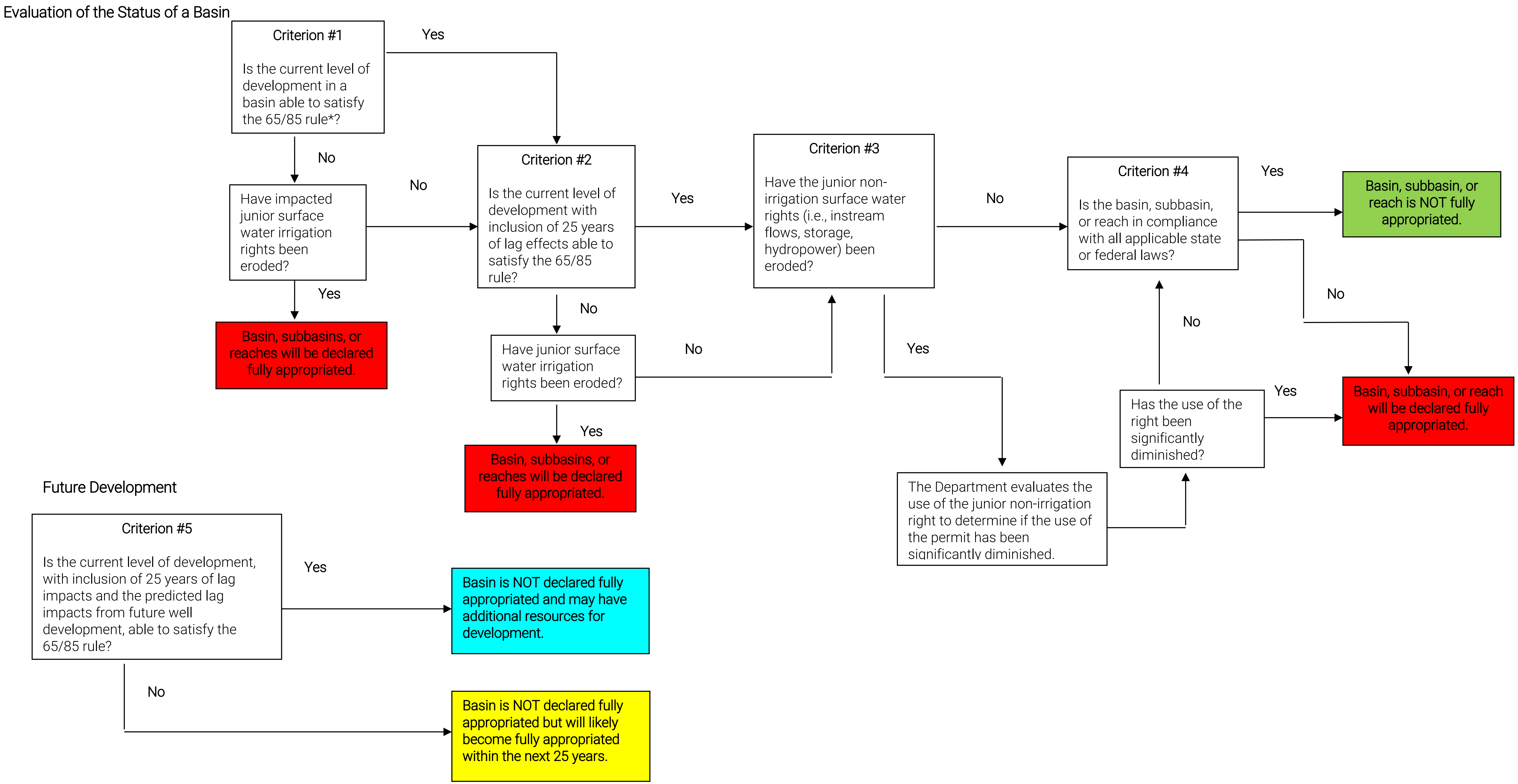
4.2 Evaluating the Status of a Basin

To evaluate the status of a basin, the Department must evaluate the current and future water supplies of the basin. The following provides a general overview of the process used by the Department to evaluate the current and future water supplies in each basin, as well as the specific step-by-step procedures implemented by the Department.

4.2.1 The Process of Determining if a Basin is Fully Appropriated

When determining the status of a basin, the Department evaluates five criteria: 1) that current levels of surface water and groundwater development, without consideration of lag impacts from wells, are able to satisfy the 65/85 rule; 2) that current levels of surface water and groundwater development, with consideration of 25-year lag impacts, are able to satisfy the 65/85 rule; 3) that erosion of non-irrigation surface water rights has not occurred, based on the standard of interference established by the Department; 4) that the basin, subbasin, or reach is in compliance with all applicable state and federal laws; and 5) that future development of groundwater in the basin (including lag impacts) will not cause the basin to be unable to satisfy the 65/85 rule.

If criteria one and/or two are not satisfied, then an additional test, the “erosion rule,” is applied to junior irrigation rights. This is used to evaluate whether the ability to divert water by the most junior surface water irrigation appropriation has been eroded. Methods for implementation of the erosion rule are discussed in detail in Section 4.2.4. Figure 4-1 illustrates the evaluation process for determining whether a basin is fully appropriated.



- In general terms, the 65/85 rule states that the surface water supply is deemed to be insufficient if, at current levels of development, the most junior irrigation right in a basin, subbasin, or reach has been unable to divert sufficient surface water over the last 20 years to provide 85 percent of the amount of water a corn crop needs (the net corn crop irrigation requirement) during the irrigation season (May 1 through September 30), or if the most junior irrigation right in a basin, subbasin, or reach is unable to divert 65 percent of the amount of water a corn crop needs during the key growing period of July 1 through August 31.

Figure 4-1. Basin evaluation flow chart.

Failure to satisfy criteria one, two, three, or four will cause a basin to be declared fully appropriated. Failure to satisfy criterion five alone will not cause a basin to be declared fully appropriated, but such failure would indicate that future development may cause the basin to become fully appropriated if current development trends continue.

4.2.2 Evaluation of Current Water Supplies

The first criterion assessed to determine whether a basin is fully appropriated is to evaluate if the current water supply is sufficient to satisfy the 65/85 rule. The current water supply is estimated based on the most recent 20-year period of streamflows (1996-2015). The following steps were taken to determine if current water supplies are sufficient to satisfy the 65/85 rule:

1. Determine the level of surface water administration that has occurred in each basin for the past 20 years.
2. Determine the crop irrigation requirement for junior irrigators subject to the administration.
3. Determine the number of days of diversion necessary to satisfy the 65/85 rule.
4. Compare the number of days available for diversion to the number of days necessary to satisfy the 65/85 rule.

Step 1: Determine the Level of Surface Water Administration in the Past 20 Years

The level of surface water administration is determined based on Department records for calls for administration during the most recent 20-year period. The administration records are used to develop a 20-year average number of days for which administration was not occurring (days available for diversion). The days available for diversion are categorized based on the months in which they are available. Days that are available for diversion during July and August are categorized as available to meet the 65 percent portion of the 65/85 rule and days that are available for diversion during May, June, July, August, and September are categorized as available to meet the 85 percent portion of the 65/85 rule.

Step 2: Determine the Crop Irrigation Requirement

The net corn crop irrigation requirement (NCCIR) was developed to estimate the average minimum consumptive allocation of water necessary to yield a profitable corn crop to an individual operator. The NCCIR is used to determine the number of diversion days required for the most junior surface water appropriation to satisfy irrigation needs under the 65/85 rule. In developing the NCCIR, corn is used as the baseline crop because the most frequent beneficial use of water in all of the basins evaluated is for the irrigation of corn. The NCCIR accounts for the average evapotranspiration and average precipitation in an area and generally decreases from northwest to southeast across the state (Figure 4-2). The NCCIR distribution for each basin is set out in individual basin subsections. The method of developing the NCCIR is described in Appendix D.

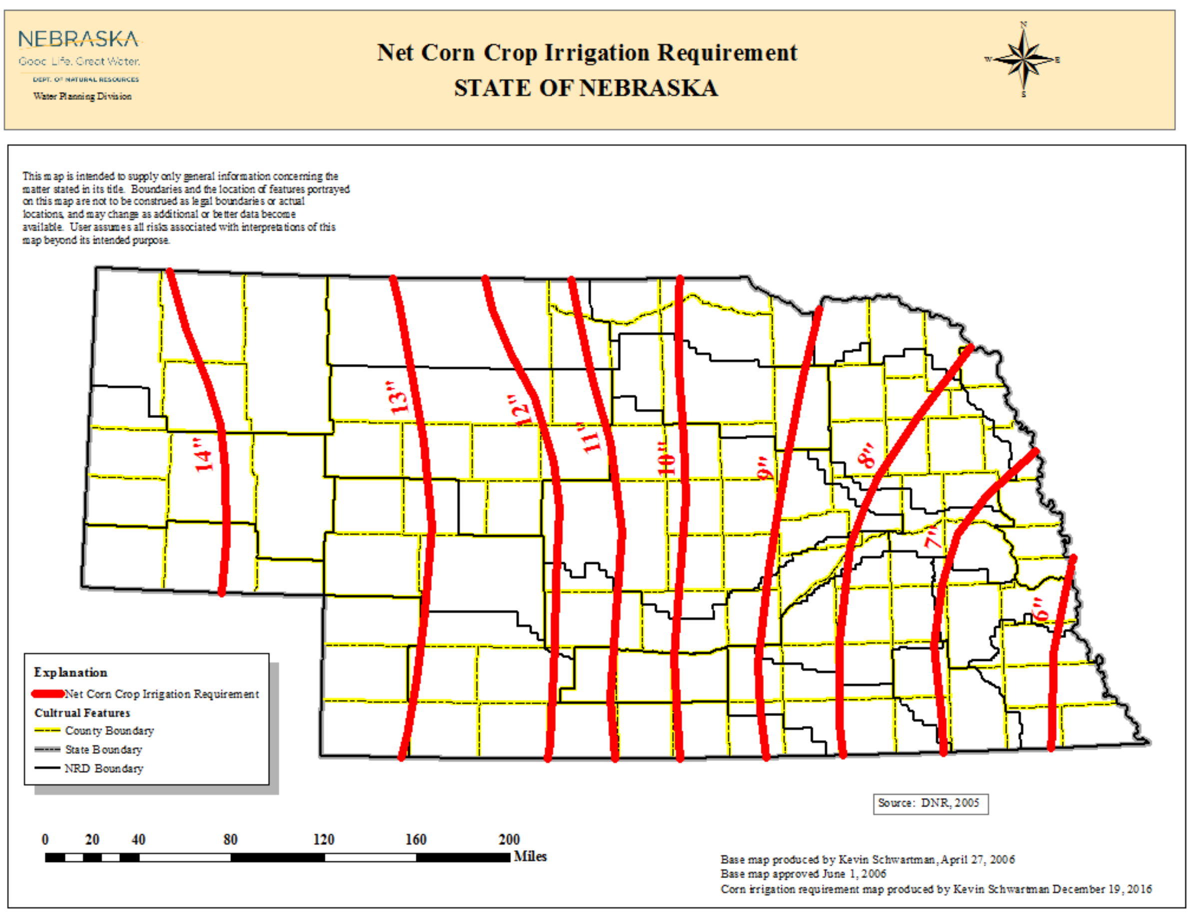


Figure 4-2. Net corn crop irrigation requirement (NCCIR).

Step 3: Determine the Number of Days Necessary for Diversion

To determine a junior irrigator's diversion requirements, the NCCIR is converted to the number of days necessary for an operator to divert water to yield a viable corn crop using these assumptions: 1) a downtime of 10 percent, due to mechanical failures and other causes; 2) a diversion rate of one cubic foot per second (cfs) per 70 acres (or 0.34 inches/day), as this is the most common rate approved by the Department for surface water appropriations; and 3) an irrigation efficiency of 80 percent. The steps to determine the number of days necessary for a specific operator to divert include the following:

1) Determine the geographic location of the junior irrigator's diversion.
2) Interpolate between the NCCIR contours to determine the specific NCCIR at the junior irrigator's diversion.
3) Multiply the NCCIR by 0.65 and 0.85 to find the 65 percent and 85 percent requirements.
4) Calculate the gross irrigation requirement by dividing the values from Step 3 by 0.8 (the irrigation efficiency).
5) Divide the gross irrigation requirement by 0.34 inches per day (rate of diversion) and by 0.9 (to account for downtime) to determine the number of days of diversion necessary for an operator.

$$\text{Number of days necessary} = \frac{\text{gross requirement}}{(0.34)(0.9)}$$

Step 4: Compare the Number of Days Available for Diversion to the Number of Days Necessary for the Junior Irrigator to Satisfy the 65/85 Rule

The results of the calculation in Step 3 are compared to the results of Step 1, the average number of days over the most recent 20-year period that surface water was available for diversion, to evaluate whether a basin is fully appropriated. If the average number of days available for diversion is less than the number of days necessary to meet either the 65 percent or 85 percent criteria, then the basin, subbasin, or reach may be declared fully appropriated.

This test is the first criterion in the five-tiered test described at the beginning of Section 4.2. If the basin satisfies this test, then the second criterion is evaluated: the addition of lag impacts from current development.

4.2.3 Evaluation of Long-Term Water Supplies with Current Levels of Development

The second criterion assessed to determine whether a basin is fully appropriated is to evaluate if the long-term water supply is sufficient to satisfy the 65/85 rule. The long-term water supply is estimated based on the most recent 20-year period of streamflows and the lag impacts from current levels of well development.

For those areas where an appropriate numerical model was available to calculate the lag depletions, the Lower Niobrara River Basin and the Loup River and Upper Elkhorn River subbasins of the Lower Platte River Basin, the model documentation describes how the analyses were conducted to calculate the lag impacts. For areas in which the appropriate geologic and hydrologic data were not available, the lag impacts were not calculated. In those cases, the number of days in which surface water was available for diversion far exceeded the number of days necessary to meet the NCCIR, and the final conclusion would likely not change even with the addition of lag impacts.

In those basins for which the appropriate geologic and hydrologic data were available and no numerical model simulations currently exist (Blue River basins, Bazile Creek, and portions of the Lower Platte River Basin), the following steps were taken to compute the lag impact from current development:

1. Define the groundwater boundary for the study area.
2. Extract all high-capacity wells with completion dates prior to December 31, 2015, from the Department’s database.
3. Account for current year’s development.
4. Estimate the volume of water pumped from each well.
5. Calculate the 25-year lag impacts.

6. Create lag-adjusted flow record.
7. Determine number of diversion days available.

Step 1: Define the Study Area Boundaries

The study area surface water boundary for each river basin is defined by the watershed boundary. The study area groundwater boundary is defined by certain features that include the location of perennial baseflow streams, areas where the aquifers are present, and the location of glaciated areas.

Wells may be influenced by hydrologic boundaries (i.e., streams in other surface water basins). The methods used to account for these boundaries rely on image wells and superposition. These methods are further described in Jenkins (1968b).

Step 2: Identify High-Capacity Wells within the Study Area

In calculating lag impacts, the Department evaluates only high-capacity wells, considered to be those wells with a pumping rate of greater than 50 gallons per minute (gpm). High-capacity wells include active irrigation, industrial, public water supply, and unprotected public water supply wells (i.e., public water supply wells without statutory spacing protection). Other wells, such as decommissioned or inactive high-capacity wells, livestock watering wells, and domestic wells were not included because the Department's water well registration database is not complete for those well types. This omission is not considered significant because these wells use relatively small amounts of water. All active high-capacity wells with a completion date prior to December 31, 2015, were used in the analysis.

Step 3: Account for Current Year (2015) Development

Wells are not registered simultaneously with their completion date, so it was necessary to estimate the number of high-capacity wells that will be registered as constructed between January 1, 2016, and December 31, 2016. The first step in estimating the number of high-capacity wells for 2016 is to average the well development rates within a basin over the previous three-year period (2013-2015). Based on the rates, additional wells are randomly located geographically within the study area on soils that have been defined by the U.S. Department of Agriculture as irrigable. To ensure that the land where the additional wells were placed was available for development, a 1,400-foot-radius circle (slightly larger than the radius of an average center pivot) was drawn around each active high-capacity well existing in the Department's water well registration database. All lands within the circles were removed from the inventory of irrigable land available for development. In addition, all irrigable land areas of less than 40 acres in size that were available for new development were excluded. The wells extracted from the Department's water well registration database with a completion date prior to December 31, 2015, and those estimated to be developed in each basin in 2016 were then combined to serve as the basis for current well development.

Step 4: Estimate the Volume Pumped by Each Well

The volume pumped from a well for consumptive use (Qt) is determined by multiplying the NCCIR (see Section 4.2.2) by the number of acres irrigated by the well. The number of acres irrigated by each well was estimated to be 90 acres for reasons documented in Appendix E (DNR, 2005). Industrial and public water supply wells are treated the same as irrigation wells for this analysis.

Example:

If Location of well: Custer County, Nebraska
NCCIR requirement (from Figure 4-2): 11 inches/year
Number of acres served: 90 acres

Then Qt: 11 inches/year * 90 acres = 990 acre-inches/year or 82.5 acre-feet/year

Step 5: Calculate 25-Year Lag Impacts

In the Bazile Creek subbasin of the Missouri Tributary Basins and the portions of the Lower Platte River Basin not covered by the CENEB groundwater model, the Jenkins SDF methodology was utilized to estimate the 25-year lag impacts to streamflows due to current well development. The Jenkins SDF methodology allows for calculation of the streamflow depletion percentage of each well in the basin. The terms used in this methodology include the depletion percentage term and the dimensionless term, both defined below:

Depletion percentage term: v/Qt

Dimensionless term: $\frac{tT}{a^2S}$ or $\frac{t}{sdf}$

The goal of this analysis is to solve for the 'v' term, or the volume of stream depletion (in acre-feet/year) over the 25-year period. First, the dimensionless term is calculated using the following known variables:

- *t* is the time since the well was completed,
- *T* is the aquifer transmissivity,
- *S* is the aquifer specific yield,
- *a* is the perpendicular distance from the well to the nearest perennial stream.

Next, the dimensionless term is used to determine the percentage of depletion (v/Qt). For example, if the dimensionless term is equal to 0.7, then the depletion percentage is equal to 0.211, or 21.1 percent (Figure 4-3).

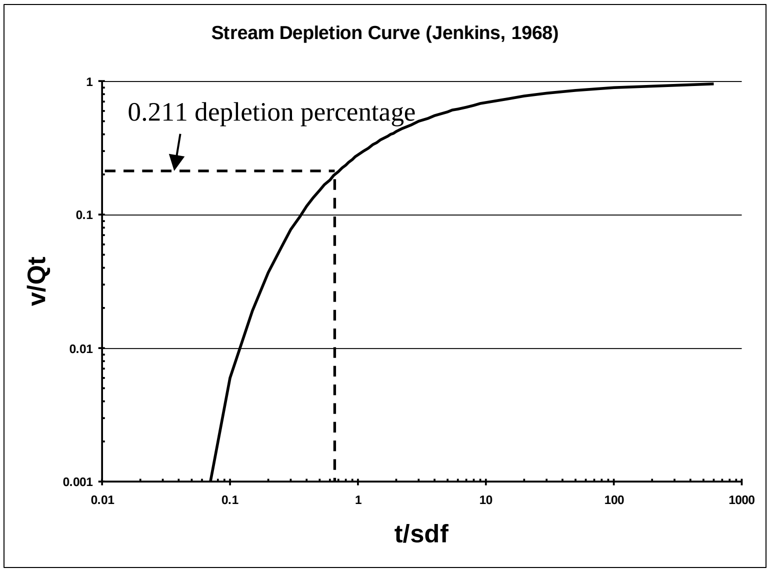


Figure 4-3. Determining depletion percentage (v/Qt) from the dimensionless term.

Finally, the stream depletion is calculated as follows:

v = Qt * depletion percentage

Where *v* = stream depletion in acre-feet/year

Qt = volume pumped in acre-feet/year

percentage depletion = value corresponding to the dimensionless term, from the graph in

Figure 4-3.

The depletion percentage is multiplied by the volume pumped, as calculated in Step 4, to determine total stream depletion. These results can be converted from annual acre-feet of depletion to cubic feet per second (cfs) by dividing by 724.46 (the conversion factor for acre-feet/year to cfs).

The next step is to calculate the 25-year lag impacts. The 25-year lag impacts for all current wells are calculated in a similar way, except that the time period for each well (t) is increased by 25 years (9,125 days). The depletion rate calculated for 2016 is subtracted from the depletion rate calculated for 2041 (25 years into the future) to determine the lag impacts. An example of this process is illustrated below (Table 4-1).

Table 4-1. Example calculation of 25-year lag impacts. The lag depletion is calculated by subtracting the rate of annual depletion in 25 years from the current rate of annual depletion.

<table>
<tr><th>Year</th><th>Cumulative Depletion (cfs)</th><th>Rate of Annual Depletion (cfs)</th><th>Lag (cfs)</th></tr>
<tr><td>2015</td><td>100</td><td rowspan="2">10</td><td rowspan="4">20</td></tr>
<tr><td>2016</td><td>110</td></tr>
<tr><td>2040</td><td>300</td><td rowspan="2">30</td></tr>
<tr><td>2041</td><td>330</td></tr>
</table>

Step 6: Create Lag-Adjusted Flow Record

The 25-year lag impacts from all current wells within a basin are summed to generate a total stream depletion value for the basin. A daily historic flow record is developed from stream gage data for the previous 20-year period to represent variations in climate and precipitation in the basin. The sum of the lag impacts is subtracted from the daily historic record to develop a new flow record, here termed the “lag-adjusted flow record.”

Step 7: Determine the Number of Days Available for Diversion

The lag-adjusted flow record is used to adjust the number of days available for diversion to the most junior appropriator within the basin based on administration records for the past 20 years. The new average number of days available for diversion is compared to the number of days necessary for the most junior surface water appropriator to divert in the basin. If the number of days necessary to meet either the 65 percent or 85 percent criterion is more than the average number of days available for diversion, then the basin, subbasin, or reach may be declared fully appropriated.

4.2.4 Determining Erosion of Rights

If a basin has failed either the first or second criterion (described in Sections 4.2), then the next step in the Department’s analysis is to apply what has been termed “the erosion rule” (*457 Neb. Admin. Code* Chapter 24, § 001.01C). This rule takes into account the fact that appropriations may be granted even though water supplies may be insufficient at the time the appropriation is granted to satisfy the requirements of 65/85 rule. If an appropriation is unable to divert enough water to satisfy the requirements of the 65/85 rule, then the second evaluation is completed to determine if the right has been "eroded," (i.e., if enough water was not available to satisfy the rule at the time the appropriation was granted, then is there less water available now).

In the event that the junior water right is not an irrigation right, regulation *457 Neb. Admin. Code* Chapter 24, § 001.01B states that the Department will utilize a standard of interference appropriate for the type of use to determine whether flows are sufficient for the use, taking into account the purpose for which the appropriation was granted.

The erosion rule is applied using historic streamflow data in a two-step process. The first step is to calculate the average number of days the most junior surface water appropriator would have been able to divert during the 20-year period before the priority date of the appropriation. The second step is to calculate the average number of days the same junior surface water appropriator has been able to divert during the most recent 20-year period. If the number of days available for diversion has decreased, then the right has been eroded. When making these calculations, the Department takes into account the lag effect of wells existing at the time of the priority date, as well as lag impacts from current well development.

The steps for determining whether a right has been eroded are as follows:

1. Gather the daily streamflow records from the 20-year period prior to the appropriation being granted.
2. Gather the daily streamflow records for the most recent 20-year period to serve as the current 20-year period.
3. Determine the 25-year lagged groundwater depletions from wells existing on the date the junior surface water appropriation was granted, and subtract them from

the daily streamflow record for the 20-year period prior to the granting of the appropriation.

4. Determine the 25-year lagged groundwater depletions from wells existing at the end of the current 20-year period (using methodologies described in Section 4.2.3), and subtract them from the daily streamflow record for the most recent 20-year period.
5. Conduct a month-by-month comparison of the average number of days available for the junior surface water appropriation to divert during the 20-year period prior to the appropriation and the average number of days available to divert during the current 20-year period.

If the average number of days available to the junior surface water appropriation for diversion during the most recent 20-year period is less than the number of days available to the junior surface water appropriation for the 20-year period prior to the appropriation, then the appropriation is deemed to be eroded.

4.2.5 Evaluation of Compliance with State and Federal Laws

To evaluate compliance with state and federal law, pursuant to *Neb. Rev. Stat.* § 46-713(3)(c), it was determined that, currently, only the state and federal laws prohibiting the taking of threatened and endangered species could potentially raise compliance issues. The federal Endangered Species Act (ESA), 16 U.S.C. §§ 1530 *et seq.*, prohibits the taking of any federally listed threatened or endangered species of animal by the actual killing or harming of an individual member of the species (16 U.S.C. § 1532) or by the significant modification or degradation of designated critical habitat where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering (50 CFR § 17.3). The state Nongame and Endangered Species Conservation Act (NNESCA), *Neb. Rev. Stat.* §§ 37-801 *et seq.*, also prohibits the actual killing or harming of an individual member of a listed species, and the destruction or modification of designated critical habitat. It was concluded that any reductions in flow that may occur as a result of not determining a basin, subbasin, or reach to be fully appropriated will not cause noncompliance with either federal or state law at this time in any of the basins evaluated.

4.2.6 Evaluating the Impacts of Predicted Future Development in a Basin

The Department is required by *Neb. Rev. Stat.* § 46-713(1)(b) to project the impact of reasonable future development within a basin on the potential for fully appropriated status. The results of this analysis alone cannot cause a basin to be declared fully appropriated; however, the analysis does provide an estimate of the effects of current well development trends on the basin's future status.

The steps necessary to calculate the impacts of future development on streamflows parallel the steps outlined in Section 4.2.3. The specific steps necessary to conduct an analysis of the impacts of future well development on the status of a basin are as follows:

1. Gather information on lag impacts of current wells (from calculations performed in Section 4.2.3).
2. Project the rate of future well development.
3. Incorporate projected future well development into the study area.
4. Calculate the depletions of projected future well development.
5. Subtract the depletions of projected future well development from the most recent 20-year lag-adjusted flow record, and recalculate the number of days available for diversion for the most junior surface water appropriation.

Step 1: Gather Information on Lag Impacts of Current Wells

The lag impacts from current well development are determined as outlined in Section 4.2.3 above, and the lag-adjusted flow record developed in Step 6 of Section 4.2.3 is that discussed in this section. In using the lag-adjusted flow record, the 25-year lag impacts of current well development are accounted for, and the impacts from future wells can be removed directly from this new flow record.

Step 2: Project Future Well Development

When calculating impacts from future wells, the rate of future well development must be estimated. This estimation is completed by projecting the linear trend of current high capacity well development within a study area over the previous 10 years (2006-2015). The yearly estimated well development for the study area is equivalent to the slope of the trend line and takes into account known limitations, such as moratoriums, on well development.

Step 3: Incorporate Future Wells into the Study Area

The number of future wells estimated in Step 2 above must be incorporated into the study area. The future wells are located geographically within the study area by randomly placing each future well on a site where the soils have been defined by the U.S. Department of Agriculture as irrigable. To ensure that the land where the future wells were placed was available for development, a 1,400-foot-radius circle (slightly larger than the radius of an average center pivot) was drawn around every existing well, and all lands already irrigated within the circles were removed from the inventory of irrigable lands that are available for development. In addition, all irrigable land areas of less than 40 acres in size that are available for new development were excluded.

Step 4: Calculate the Lag Impacts of Future Wells

Depletions from future wells are calculated following the same methodology outlined in Section 4.2.3. The depletions of future wells are calculated independently of current well development. The 25-year depletions from future well development are removed from the lag-adjusted flow record created in Step 6 of Section 4.2.3 to develop the future lag-adjusted flow record.

Step 5: Create a Historic Flow Record with Lag Impacts from Current and Future Well Development

The historic record, with the 25-year lag impacts from all current wells created at the end of Step 6 in Section 4.2.3 subtracted (i.e., the lag-adjusted flow record), is used as the starting point in developing the future lag-adjusted flow record. The depletions from future wells incorporated into the study area are calculated for each year through the 25-year period and subtracted from the lag-adjusted flow record.

The sum of the future depletions is subtracted from the lag-adjusted daily flow record for the most recent 20-year period to create a future adjusted flow record to account for all current well lag impacts and potential future well depletions. The future lag-adjusted flow record is then used to calculate the average number of days available for diversion to the most junior appropriator within the basin. This new future lag-adjusted flow record is compared to the number of days necessary for the most junior surface water appropriator to divert in the basin.

In those basins for which the appropriate geologic and hydrologic data were not available, the impacts of future well development were not calculated due to uncertainty of the degree of hydrologic connection. In many of those cases, the number of days in which surface water is available for diversion far exceeds the number of days necessary to meet the NCCIR, and the final conclusion would likely not change even with the addition of lag impacts.

4.3 Development of the 10/50 Areas

The 10/50 area is defined as the geographic area within which groundwater is hydrologically connected to surface water. A groundwater well that is constructed in the 10/50 area would deplete river flow by at least 10 percent of the water pumped over a 50-year period. The 10/50 areas are not dependent on the quantity of water pumped, but rather on each basin's geologic characteristics and the distance between each well and the stream.

4.3.1 Numerical and Analytical Models Used in Development of the 10/50 Areas

The Department reviewed available numerical models to assess their validity in defining the 10/50 area. The Department identified the Upper Niobrara-White Model as being a valid numerical model for defining the 10/50 area for the Lower Niobrara River Basin; the CENEB model as being a valid numerical model for defining the 10/50 area for the Lower Niobrara River Basin and portions of the Lower Platte River Basin; and the Blue Basins Model as being valid for defining the 10/50 area for the Little Blue and Big Blue River basins. The methods utilized for determining the 10/50 with each of these models is included in the report backup data available at: (ftp://dnrftp.dnr.ne.gov/Pub/FAB_Report/).

In other areas where appropriate geologic data exist (i.e., portions of the Lower Platte River Basin and portions of the Missouri Tributary Basins), an analytical methodology was used to define the 10/50 area. The following steps were taken to calculate the extent of the 10/50 area:

1. Collect and prepare data (data will be provided by the Department upon request).
2. Evaluate available data to determine if the principal aquifer is present and if sufficient data exist to determine that a given stream reach is in hydrologic connection with the principal aquifer.
3. Complete calculations to delineate the 10/50 boundary for these basins.
4. Develop the 10/50 area.

The Jenkins Method was used to determine the extent of the 10/50 area in portions of the Lower Platte River Basin (those areas outside of the CENEB model domain), and the Bazile Creek subbasin of the Missouri Tributary Basins. In all other areas, where sufficient data do not exist or where the principal aquifer is not present, the 10/50 area could not be determined at this time.

Step 1: Data Preparation

The following data are necessary for determining the extent of the 10/50 area:

- Aquifer transmissivity
- Aquifer specific yield
- Locations of perennial streams
- Point grid of distances to streams

The aquifer properties used in the study were found in the report "Mapping of Aquifer Properties – Transmissivity and Specific Yield – for Selected River Basins in Central and Eastern Nebraska" published by the Conservation and Survey Division (CSD, 2005). The location and extent of perennial streams were found in the permanent streams GIS coverage that is available from the USGS National Hydrography Dataset. The main stems of each river and of their perennial tributaries were included in the calculations for individual basins.

A point grid with a spacing of one mile was developed to identify specific distances from the stream and to store those locations that were within the 10/50 area.

Step 2: Identify Principal Aquifers and Hydrologic Connection to Perennial Streams

The extent of hydrologic connection between aquifers and streams was primarily determined from maps generated by the Conservation and Survey Division (CSD, 2005). Supporting evidence from other published reports may also be used in some cases to delineate the extent of hydrologic connection between aquifers and streams. This information is referenced where used.

Step 3: Perform Jenkins SDF Calculations

In portions of the Lower Platte River Basin and the Bazile Creek subbasin of the Missouri Tributary Basins, the Jenkins SDF method was used. The Jenkins SDF method utilizes the following two terms, for which solutions are derived graphically using the curve shown in Figure 4-4.

Depletion percentage term: v/Qt

Dimensionless term: $\frac{t}{sdf}$

Where *v* = volume of stream depletion during time t

Qt = net volume pumped during time t

t = time during the pumping period since pumping began

$sdf = \frac{a^2 * S}{T}$

Where *a* = perpendicular distance between the well and stream

S = average specific yield of the aquifer between the well and the stream

T = average transmissivity of the aquifer between the well and the stream.

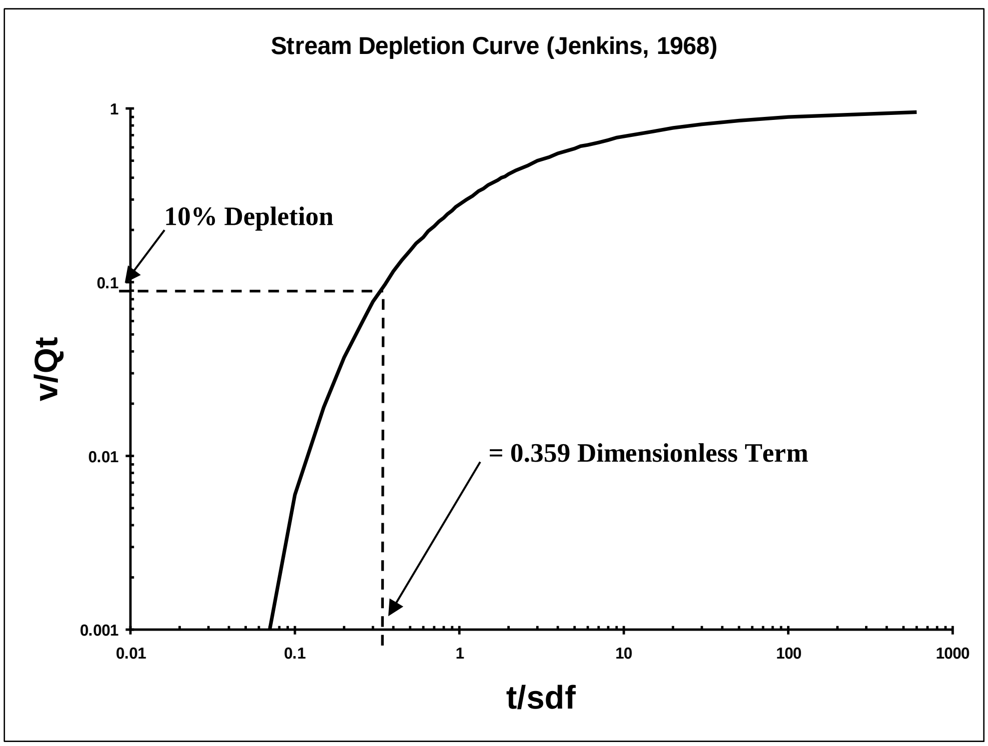


Figure 4-4. Stream depletion curve from Jenkins (1968). The dimensionless term will equal 0.359 when the depletion percentage is equal to 10 percent. The aquifer properties (transmissivity and specific yield) at each grid point and the distance of each grid point from the nearest perennial stream will be utilized to calculate the dimensionless term.

Figure 4-5 illustrates an example of the data used in the determination of the dimensionless term at each point. The known values for the 10/50 calculation are as follows:

- *t* is 50 years, or 18,262 days,
- *T* is the aquifer transmissivity,
- *S* is the aquifer specific yield,
- *a* is the perpendicular distance from the grid point to the nearest perennial stream.

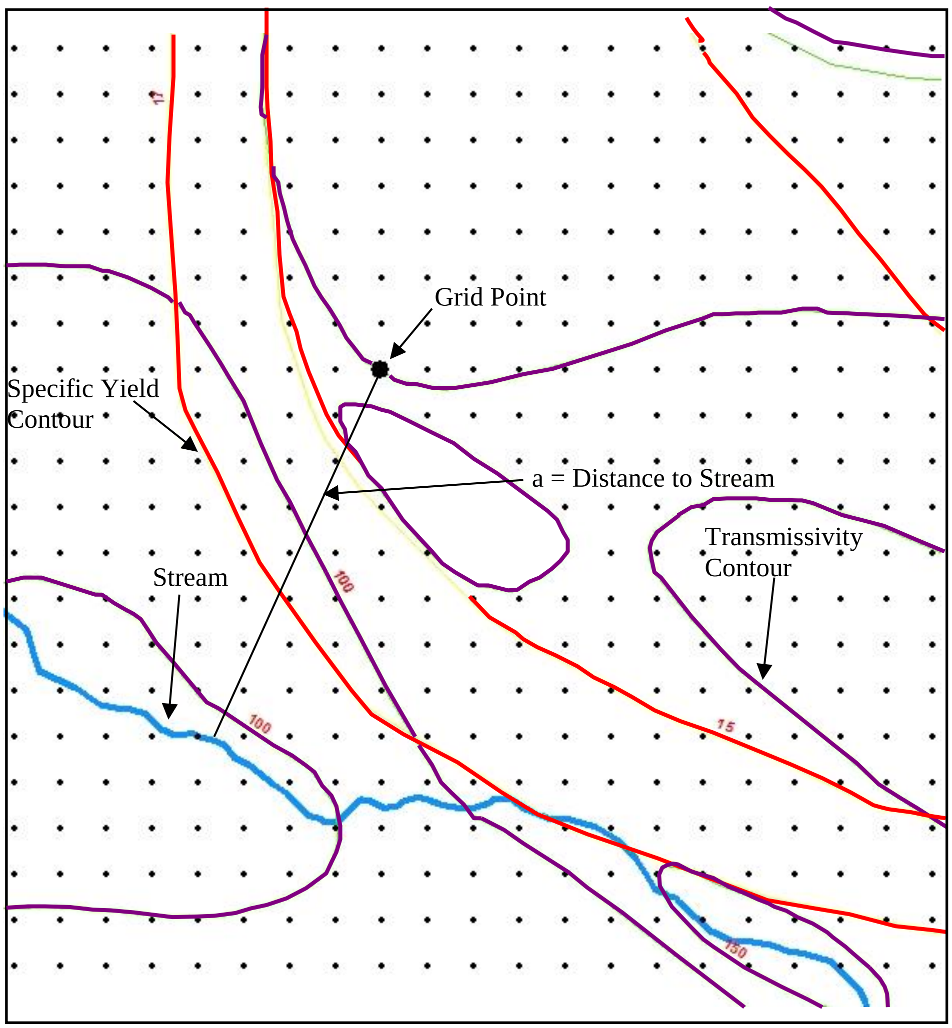


Figure 4-5. An example of the data and method used in determination of the 10/50 area. The purple and red lines are isolines (constant value along that line). Transmissivity and specific yield values for individual points are interpolated between the two nearest contour lines.

Step 4: Developing the 10/50 Area

Once the value for the dimensionless term is derived, those grid points with a dimensionless term value greater than 0.359 are included as part of the 10/50 area. All points that meet this requirement are merged to develop the complete 10/50 area for the basin.

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5.0 BLUE RIVER BASINS

5.1 Summary

Based on the analysis of the sufficiency of the long-term surface water supply in the Blue River Basins, the Department has reached a preliminary conclusion that the basins are not fully appropriated. The Department has also determined that, based on current information, if no additional legal constraints are imposed on future development of hydrologically connected surface water and groundwater, and reasonable projections are made about the extent and location of future development, this preliminary conclusion would not change to a conclusion that the basin is fully appropriated.

The analysis of lag effects of current development for areas in the Big Blue River Basin indicates a reduction in streamflows by 12 cfs in 25 years. The analysis of lag effects of current development for areas in the Little Blue River Basin indicates a reduction in streamflows by 17 cfs in 25 years.

The analysis of the impacts of potential future development in the Big Blue River Basin, based on current development trends, indicates an additional reduction in streamflows of 3 cfs in 25 years. The analysis of the impacts of potential future development in the Little Blue River Basin, based on current development trends, indicates an additional reduction in streamflows of 10 cfs in 25 years.

5.2 Basin Descriptions

The Blue River Basins in Nebraska include all surface areas that drain into the Big Blue River and the Little Blue River and all aquifers that impact surface water flows of the basins (Figure 5-1). The total area of the Blue River surface water basins in Nebraska is approximately 7,100 square miles, of which 4,600 square miles are in the Big Blue River Basin and 2,500 square miles are in the Little Blue River Basin. NRDs with significant area in the basins are the Little Blue, the Lower Big Blue, the Upper Big Blue, and the Tri-Basin

NRDs. The basins are the subject to an interstate compact between Kansas and Nebraska that sets state line target flows.

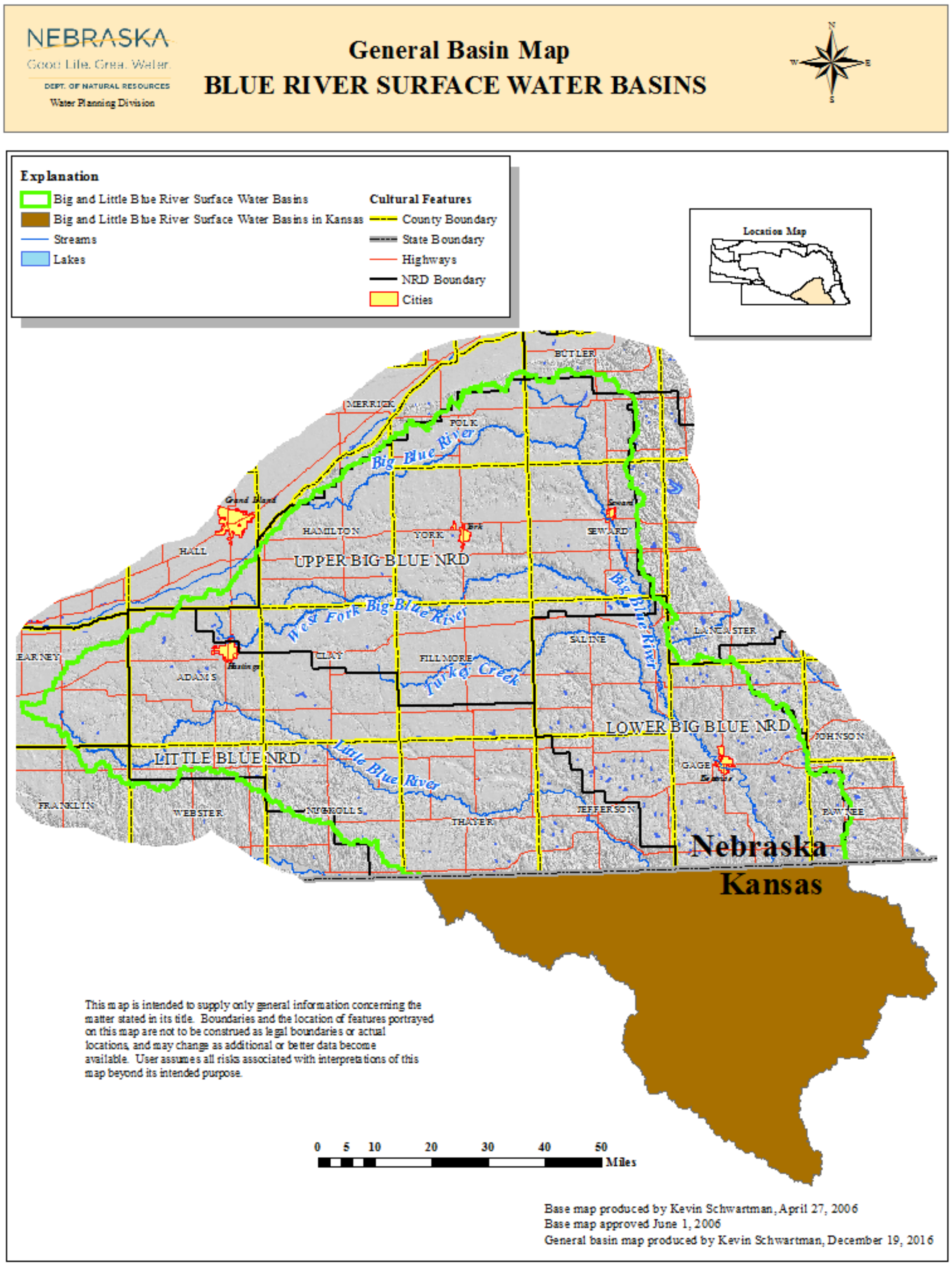

Figure 5-1. General basin map, Blue River Basins.

5.3 Nature and Extent of Water Use

5.3.1 Groundwater

Groundwater in the Blue River Basins is used for a variety of purposes: domestic, industrial, livestock, irrigation, and other uses. A total of 25,007 groundwater wells had been registered within the basins as of December 31, 2015 (Department registered groundwater wells database) (Figure 5-2). The locations of all active groundwater wells are shown in Figure 5-3.

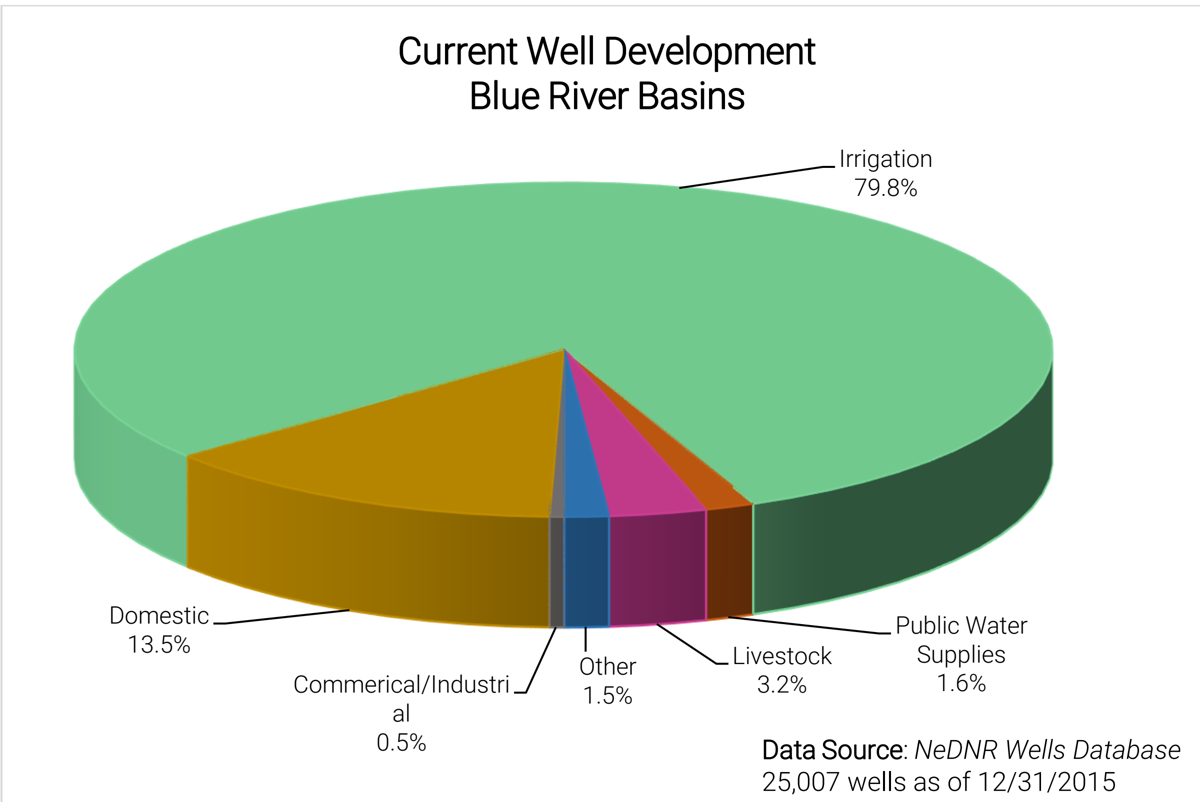

Figure 5-2. Current well development by number of registered wells, Blue River Basins.

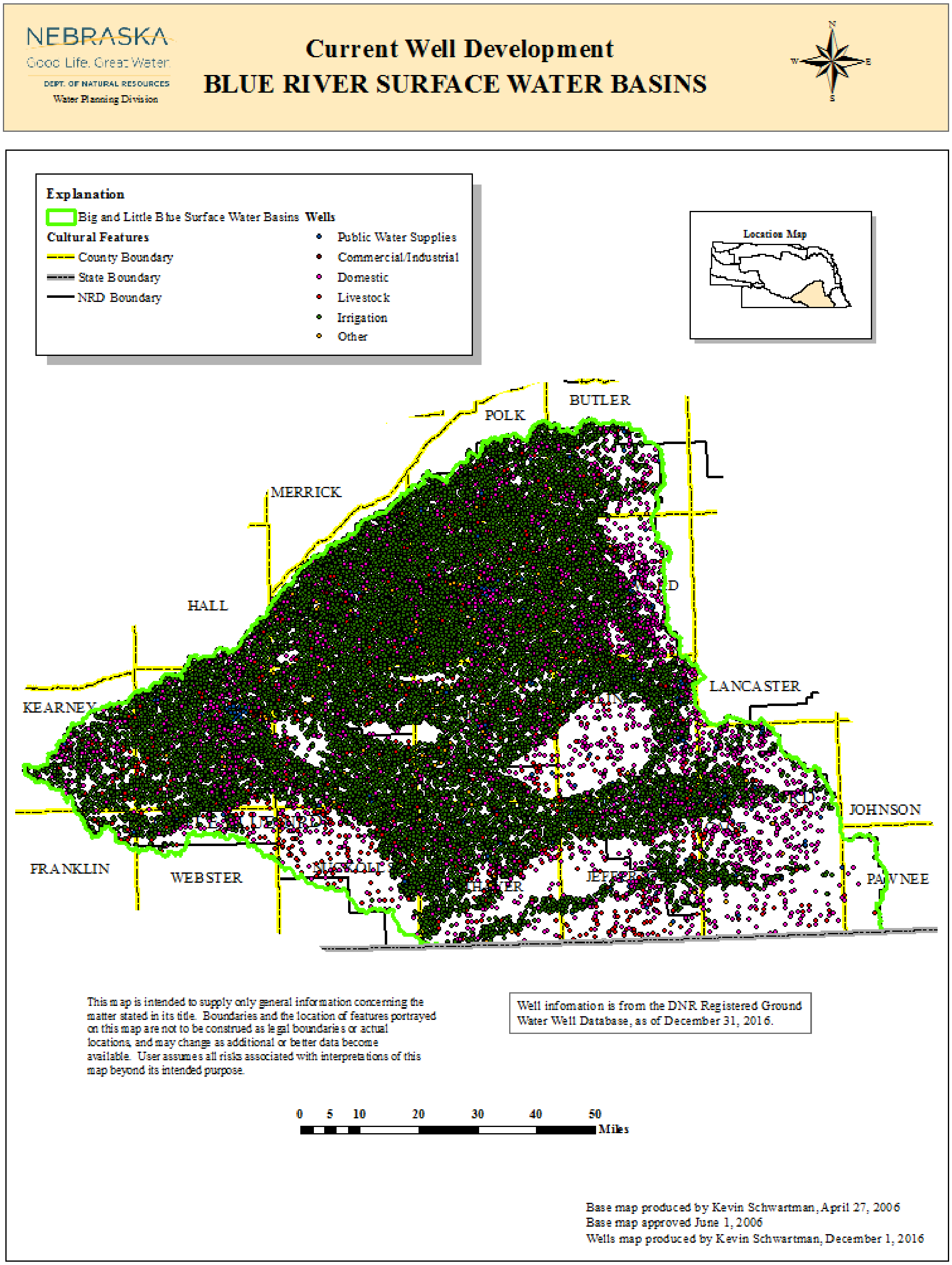

Figure 5-3. Current well locations, Blue River Basins.

5.3.2 Surface Water

As of December 31, 2015, 2,412 active surface water appropriations were held in the Blue River Basins, issued for a variety of uses (Figure 5-4). Most of the surface water appropriations are irrigation and storage uses that tend to be located on the major streams. The first surface water appropriations in the basins were permitted in 1868, and development has continued through the present day. The approximate locations of the surface water diversion points are shown in Figure 5-5.

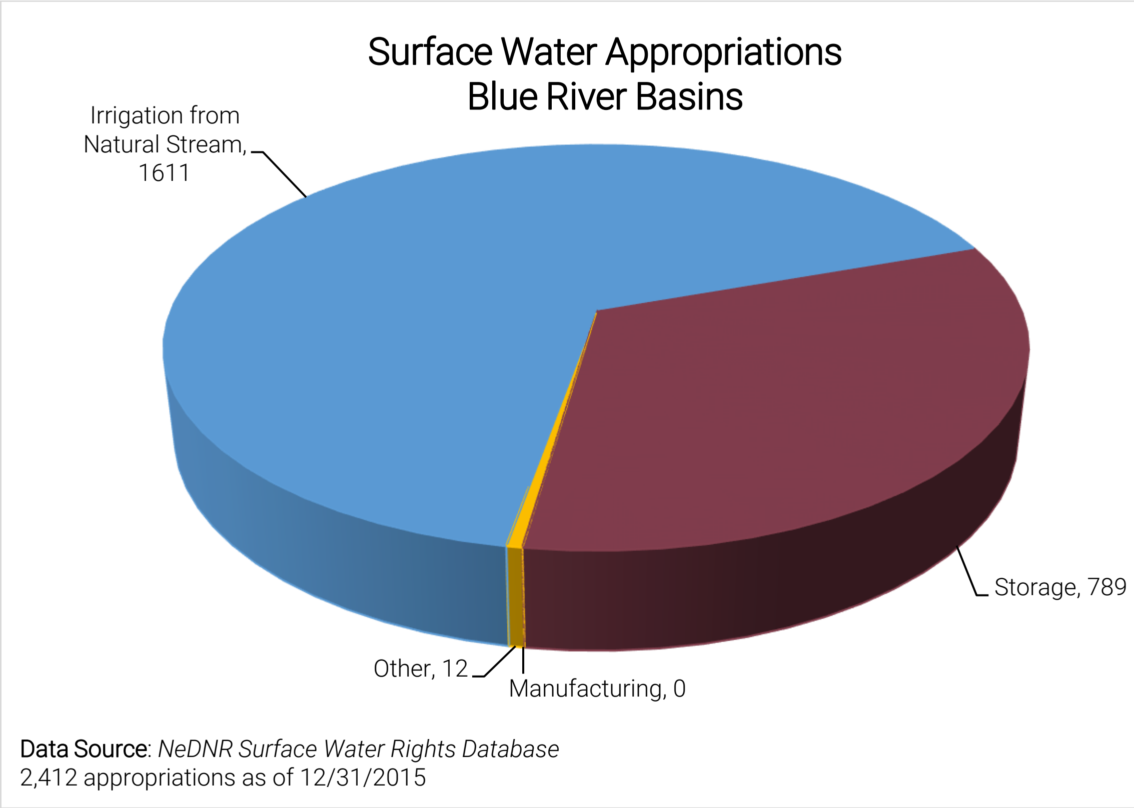

Figure 5-4. Surface water appropriations by number of diversion points, Blue River Basins.

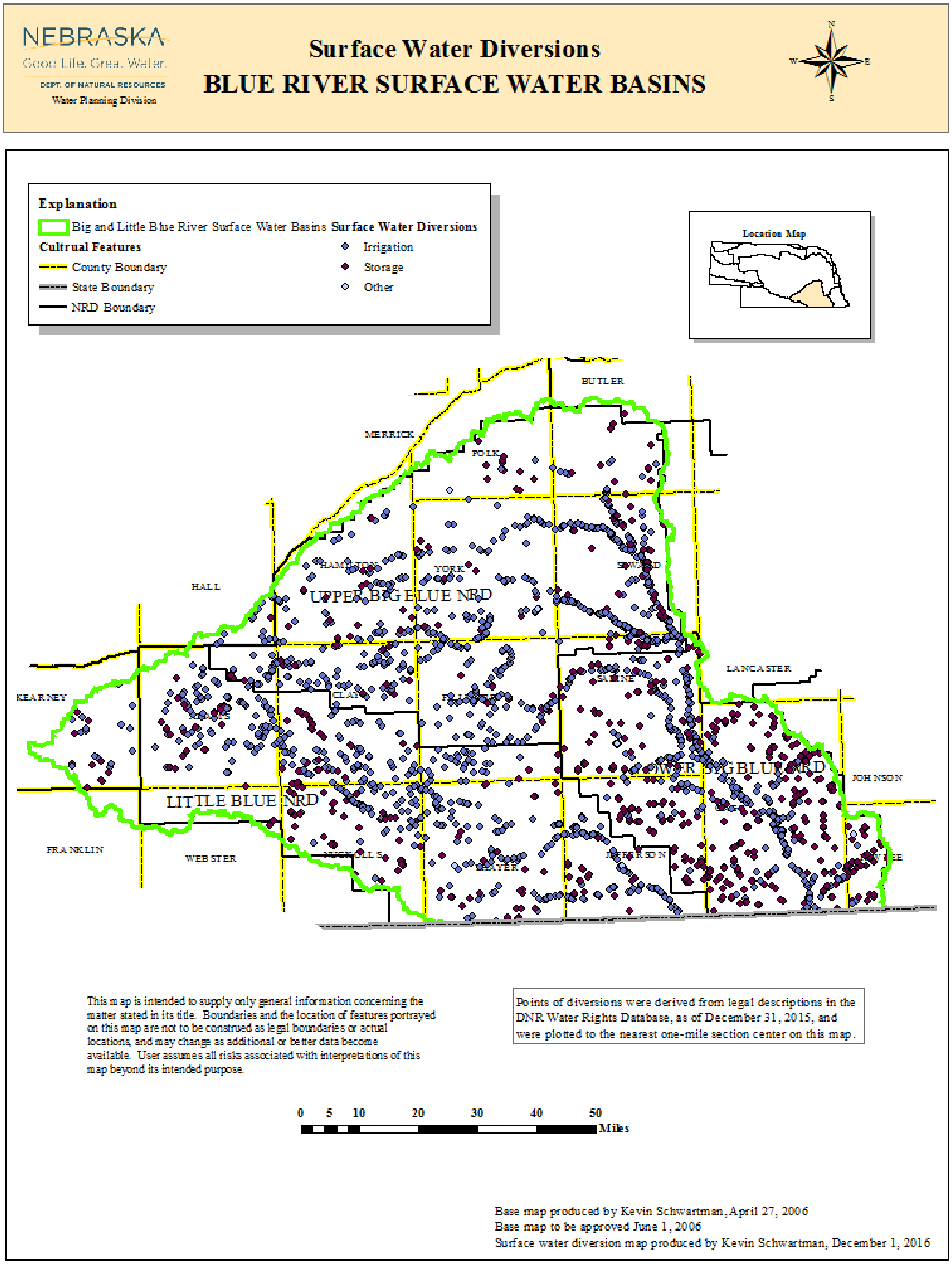

Figure 5-5. Surface water appropriation diversion locations, Blue River Basins.

5.4 Hydrologically Connected Area

The Blue Basin Model was used to determine the extent of the 10/50 area for the Blue River Basins. Figure 5-6 specifies the extent of the 10/50 area for the Little Blue River and Big Blue River basins.

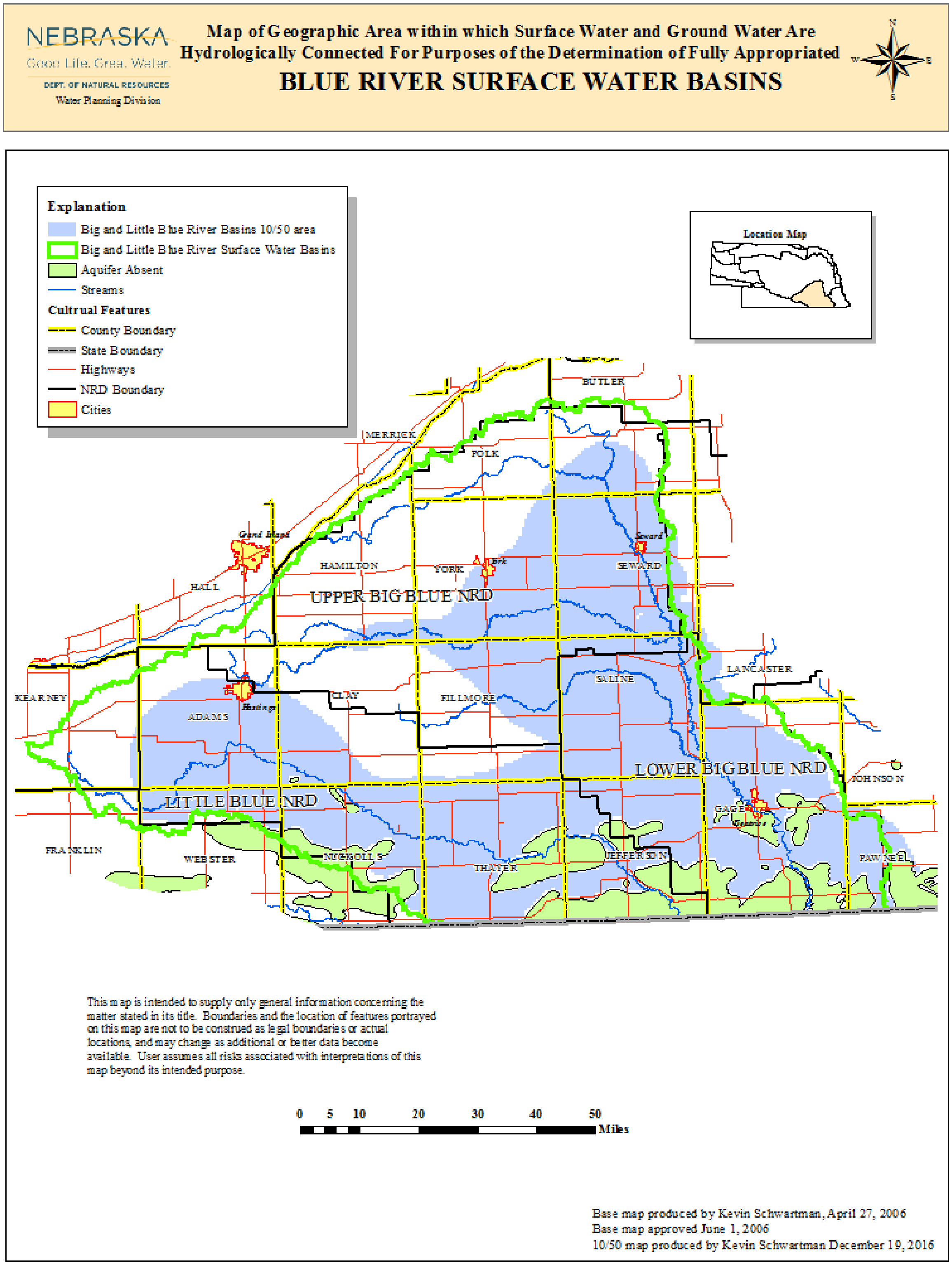

Figure 5-6. 10/50 area for the Blue River Basins.

5.5 Net Corn Crop Irrigation Requirement

Figure 5-7 is a map of the net corn crop irrigation requirement (NCCIR) for the Blue River Basins (DNR, 2005). The greatest NCCIR of a junior surface water appropriation in the Big Blue River Basin is 9.0 inches, and the greatest NCCIR in the Little Blue River Basin is 9.7 inches. To assess the number of days required for diversion, a surface water diversion rate equal to 1 cfs per 70 acres, a downtime of 10 percent, and an irrigation efficiency of 80 percent, were assumed. Based on these assumptions, the junior surface water appropriation in the Big Blue River Basin would need 23.9 days annually to divert 65 percent of the NCCIR and 31.3 days to divert 85 percent of the NCCIR. The junior surface water appropriation in the Little Blue River Basin will need 25.8 days annually to divert 65 percent of the NCCIR and 33.7 days to divert 85 percent of the NCCIR.

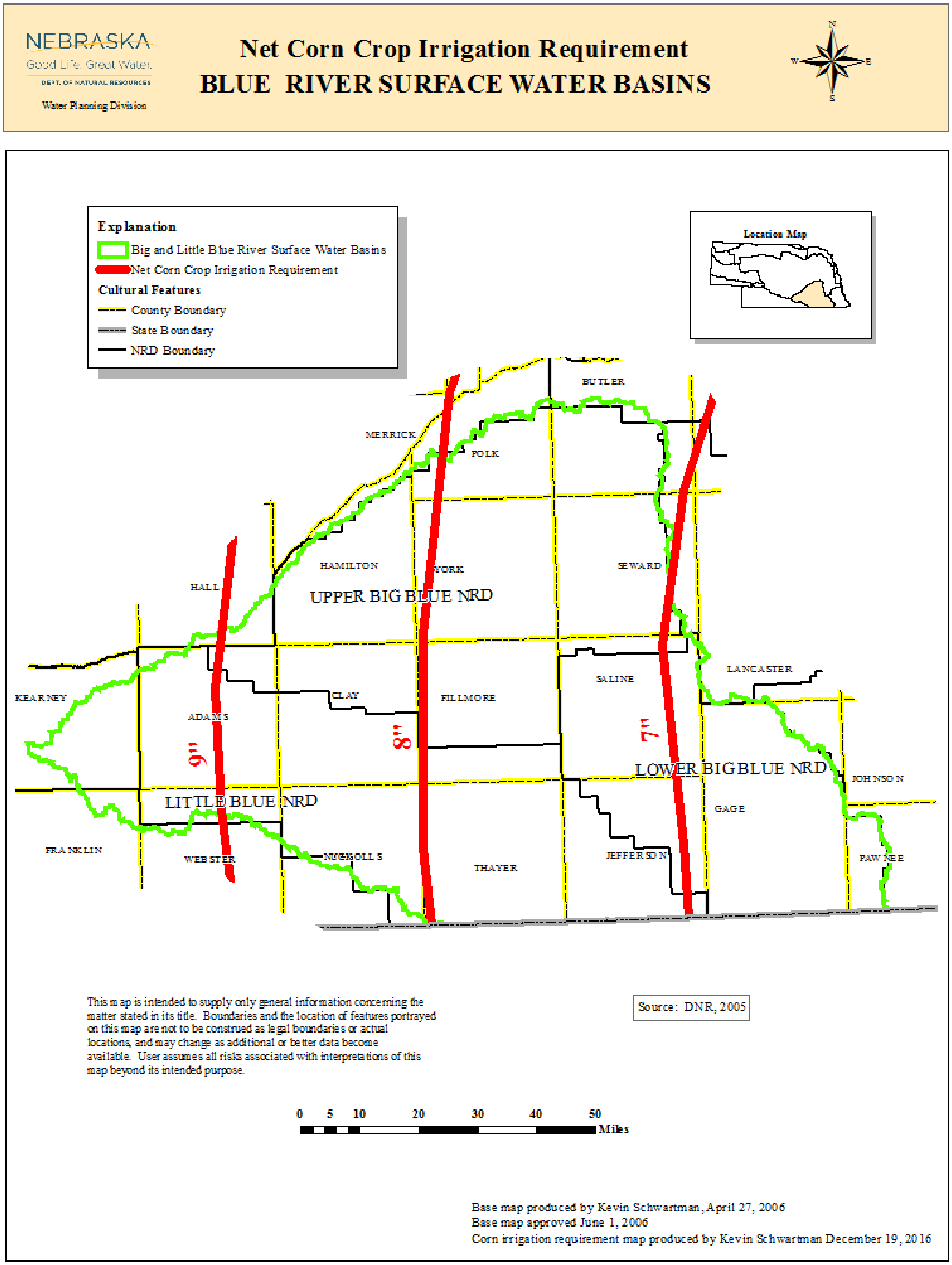

Figure 5-7. Net corn crop irrigation requirement (NCCIR), Blue River Basins.

5.6 Surface Water Closing Records

Tables 5-1 and 5-2 record all surface water administration that has occurred in the basins between 1996 and 2015.

Table 5-1. Surface water administration in the Big Blue River Basin, 1996-2015.

Year	Water Body	Days	Closing Date	Opening Date
2000	Turkey Creek	3	Jun 9	Jun 12
2000	Big Blue River above Lincoln Creek	2	Aug 15	Aug 17
2001	Big Blue River above Lincoln Creek	1	Aug 14	Aug 15
2002	Big Blue River above Lincoln Creek	11	Jul 11	Jul 22
2002	Big Blue River above Lincoln Creek	14	Jul 30	Aug 13
2002	Big Blue River Basin	8	Aug 5	Aug 13
2002	North Fork Big Blue River	1	Aug 14	Aug 15
2003	Big Blue River above Lincoln Creek	49	Jul 16	Sep 3
2003	Big Blue River Basin	11	Jul 17	Jul 28
2003	Big Blue River Basin	8	Aug 11	Aug 19
2004	Big Blue River above Lincoln Creek	16	Aug 3	Aug 19
2005	Big Blue River above Lincoln Creek	14	Jul 12	Jul 26
2005	Big Blue River Basin	13	Jul 13	Jul 26
2005	Big Blue River above West Fork	8	Jul 18	Jul 26
2005	Big Blue River above Lincoln Creek	11	Aug 4	Aug 15
2005	Big Blue River Basin	6	Aug 9	Aug 15
2005	Big Blue River above West Fork	5	Aug 10	Aug 15
2006	Big Blue River above West Fork	13	Jul 1	Jul 14
2006	Big Blue River above West Fork	22	Jul 17	Aug 8
2006	Big Blue River Basin	11	Jul 3	Jul 14
2006	Big Blue River Basin	5	Jul 19	Jul 24
2006	Big Blue River Basin	9	Jul 29	Aug 7
2012	Big Blue River Basin	83	Jul 9	Sep 30
2012	Upstream of A-2440 and A-2816	5	Jul 25	Jul 30
2013	Big Blue River Basin	19	Jul 11	Jul 30
2013	North Fork Big Blue River	23	Aug 21	Sep 13
2013	Big Blue River Basin	18	Aug 26	Sep 13
2014	Big Blue River Basin	14	Jul 29	Aug 11

Table 5-2. Surface water administration in the Little Blue River Basin, 1996-2015.

Year	Water Body	Days	Closing Date	Opening Date
2002	Little Blue River Basin	11	Jul 18	Jul 29
2002	Little Blue River Basin	13	Aug 6	Aug 19
2002	Little Blue River Basin	7	Sep 9	Sep 16
2004	Little Blue River Basin	10	Sep 13	Sep 23
2005	Little Blue River Basin	15	Jul 11	Jul 26
2005	Little Blue River Basin	7	Aug 8	Aug 15
2006	Little Blue River Basin	9	Jul 5	Jul 14
2006	Little Blue River Basin	1	Jul 20	Jul 21
2006	Little Blue River Basin	7	Jul 31	Aug 7
2006	Little Blue River Basin	8	Aug 9	Aug 17
2009	Little Blue River Basin	14	Aug 13	Aug 27
2012	Little Blue River Basin	14	Jul 20	Aug 3
2012	Little Blue River Basin	53	Aug 8	Sep 30
2013	Little Blue River Basin	22	Jul 8	Jul 30
2013	Little Blue River Basin	18	Aug 29	Sep 16
2013	Little Blue River Basin	4	Sep 27	Oct 1
2014	Little Blue River Basin	19	Jul 23	Aug 11
2015	Little Blue River Basin	5	Aug 27	Sep 1
2015	Little Blue River Basin	4	Sep 4	Sep 8

5.7 Evaluation of Current Development

5.7.1 Current Water Supply

The current water supply is estimated by using the most recent 20-year period (1996-2015) of surface water administration. The results of the analyses conducted for the Big Blue River Basin and Little Blue River Basin, respectively, are shown in Tables 5-3 and 5-4. The results indicate that the current surface water supply in the Big Blue River Basin provides an average of at least 49.9 days available for diversion between July 1 and August 31 and 138.6 days available for diversion between May 1 and September 30 (Table 5-5). The current surface water supply in the Little Blue River Basin provides an average of at least

53.5 days available for diversion between July 1 and August 31 and 141.0 days available for diversion between May 1 and September 30 (Table 5-6).

Table 5-3. Estimate of the current number of days surface water is available for diversion in the Big Blue River Basin.

Year	July 1 through August 31 Number of Days Surface Water is Available for Diversion	May 1 through September 30 Number of Days Surface Water is Available for Diversion
1996	62	153
1997	62	153
1998	62	153
1999	62	153
2000	60	151
2001	61	152
2002	36	127
2003	16	104
2004	46	137
2005	37	128
2006	27	118
2007	62	153
2008	62	153
2009	62	153
2010	62	153
2011	62	153
2012	9	70
2013	37	116
2014	48	139
2015	62	153
Average	49.9	138.6

Table 5-4. Estimate of the current number of days surface water is available for diversion in the Little Blue River Basin.

Year	July 1 through August 31 Number of Days Surface Water is Available for Diversion	May 1 through September 30 Number of Days Surface Water is Available for Diversion
1996	62	153
1997	62	153
1998	62	153
1999	62	153
2000	62	153
2001	62	153
2002	38	122
2003	62	153
2004	62	143
2005	40	131
2006	37	128
2007	62	153
2008	62	153
2009	48	139
2010	62	153
2011	62	153
2012	25	86
2013	37	109
2014	43	134
2015	58	144
Average	53.5	141.0

Table 5-5. Comparison between the number of days required to meet the net corn crop irrigation requirement and number of days surface water is currently available for diversion in the Big Blue River Basin.

	Number of Days Necessary to Meet the 65% and 85% of Net Corn Crop Irrigation Requirement	Average Number of Days Available for Diversion with Current Development
July 1 – August 31 (65% Requirement)	23.9	49.9 (26.0 days above the requirement)
May 1 – September 30 (85% Requirement)	31.3	138.6 (107.3 days above the requirement)

Table 5-6. Comparison between the number of days required to meet the net corn crop irrigation requirement and number of days surface water is currently available for diversion in the Little Blue River Basin.

	Number of Days Necessary to Meet the 65% and 85% of Net Corn Crop Irrigation Requirement	Average Number of Days Available for Diversion with Current Development
July 1 – August 31 (65% Requirement)	25.7	53.5 or greater (27.8 days above the requirement)
May 1 – September 30 (85% Requirement)	33.6	141.0 (107.4 days above the requirement)

5.7.2 Long-Term Water Supply

In order to complete the long-term evaluation of surface water supplies, a future 20-year water supply must be estimated for each basin. The Blue River Basins' water sources are precipitation, which runs off as direct streamflow and infiltrates into the ground to discharge as baseflow; and groundwater movement into the basins, which discharges as baseflow. Using methodology published in the *Journal of Hydrology* (Wen and Chen, 2005), a nonparametric Mann-Kendall trend test of the weighted average precipitation in the basins was completed. The analysis showed no statistically significant trend in precipitation ($P > 0.95$) over the past 60 years (Figure 5-8). Therefore, using the previous 20 years of streamflow data as the best estimate of the future surface water supply is reasonable.

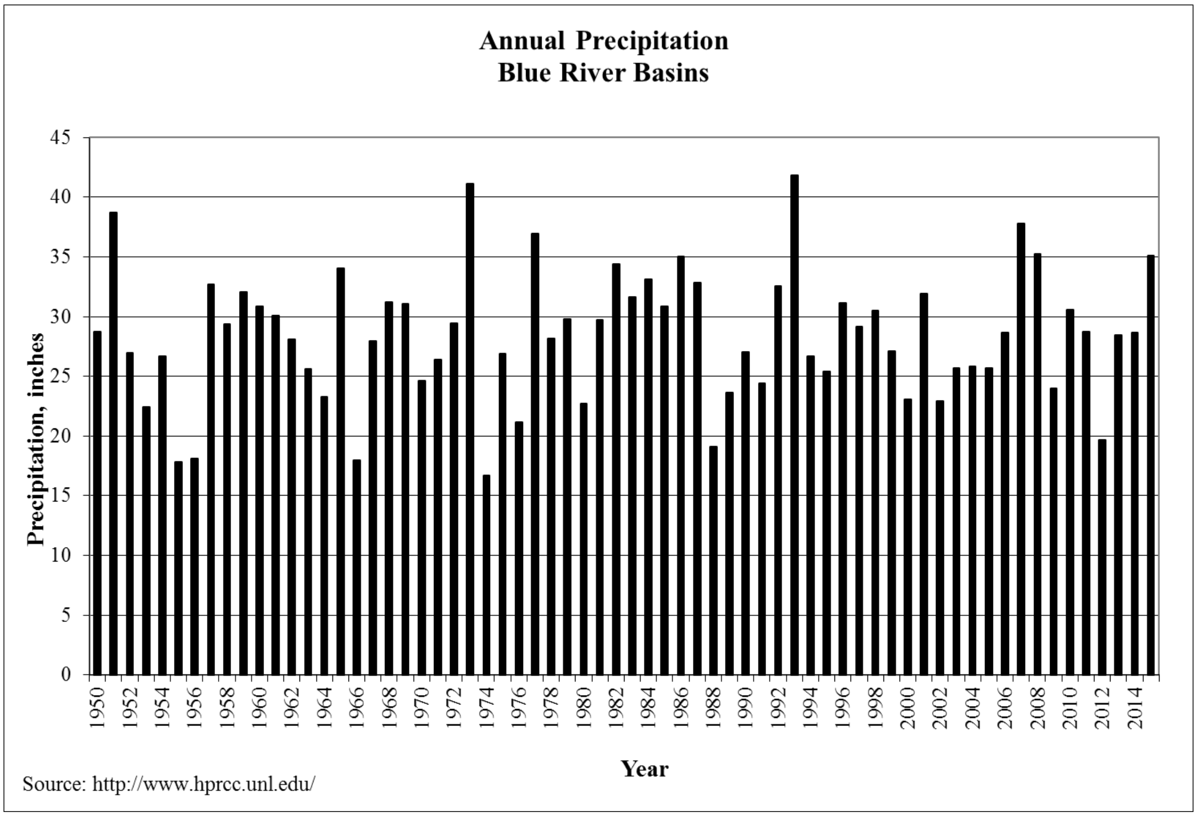

Figure 5-8. Annual precipitation, Blue River Basins.

5.7.3 Depletions Analysis

The future depletions due to current well development that could be expected to affect streamflow were estimated for the Big Blue River and Little Blue River basins using the Blue Basins Model. The results estimate the future streamflow in the Big Blue River Basin to be depleted by an additional 12 cfs in 25 years and flows in the Little Blue River Basin to be depleted by an additional 17 cfs in 25 years.

5.7.4 Evaluation of Current Levels of Development against Future Water Supplies

The estimates of the 20-year average number of days available for diversion are calculated by comparing the depleted future water supply with the flows necessary to satisfy the state line compact target flows. The results of the analyses are shown in Tables 5-7 and 5-8 and are compared to the numbers of days surface water is required to be available to divert 65 percent and 85 percent of the NCCIR in Tables 5-9 and 5-10. In all cases, the estimated long-term surface water supply, given current levels of development, is sufficient to satisfy the 65/85 rule.

Table 5-7. Estimate of days surface water is available for diversion in the Big Blue River Basin with current development and 25-year lag impacts.

Year	July 1 through August 31 Number of Days Surface Water is Available for Diversion	May 1 through September 30 Number of Days Surface Water is Available for Diversion
1	62	153
2	62	153
3	62	153
4	62	153
5	58	149
6	61	152
7	27	118
8	9	97
9	46	137
10	33	124
11	25	116
12	62	153
13	62	153
14	62	153
15	62	153
16	62	153
17	8	68
18	34	112
19	46	137
20	62	153
Average	48.4	137.0

Table 5-8. Estimate of days surface water is available for diversion in the Little Blue River Basin with current development and 25 year lag impacts.

Year	July 1 through August 31 Number of Days Surface Water is Available for Diversion	May 1 through September 30 Number of Days Surface Water is Available for Diversion
1	62	153
2	62	153
3	62	153
4	62	153
5	61	145
6	62	153
7	30	108
8	59	146
9	60	128
10	37	121
11	30	121
12	62	153
13	62	153
14	42	133
15	62	153
16	62	153
17	19	80
18	29	90
19	42	133
20	56	126
Average	51.2	135.4

Table 5-9. Comparison between the number of days required to meet the net corn crop irrigation requirement and number of days surface water is available for diversion in the Big Blue River Basin with current development and lag impacts.

	Number of Days Necessary to Meet the 65% and 85% of Net Corn Crop Irrigation Requirement	Average Number of Days Available for Diversion at Current Development with 25 Years of Lag Impacts
July 1 – August 31 (65% Requirement)	23.9	48.4 (24.5 days above the requirement)
May 1 – September 30 (85% Requirement)	31.3	137.0 (105.7 days above the requirement)

Table 5-10. Comparison between the number of days required to meet the net corn crop irrigation requirement and number of days surface water is available for diversion in the Little Blue River Basin with current development and lag impacts.

	Number of Days Necessary to Meet the 65% and 85% of Net Corn Crop Irrigation Requirement	Average Number of Days Available for Diversion at Current Development with 25 Years of Lag Impacts
July 1 – August 31 (65% Requirement)	25.7	51.2 (25.5 days above the requirement)
May 1 – September 30 (85% Requirement)	33.6	135.4 (101.8 days above the requirement)

5.8 Evaluation of Predicted Future Development

Estimates of the number of high-capacity wells (wells pumping greater than 50 gpm) that would be completed over the next 25 years, if no new legal constraints on the construction of such wells were imposed, were calculated based on extrapolating the present-day rate of increase in well development into the future (Figures 5-9 and 5-10). The present-day rate of development is based on the linear trend of the previous 10 years of development in the basins. Based on the analysis of the past 10 years of development, the rate of increase in high-capacity wells is estimated to be 71 wells per year in the Big Blue River Basin and 91 wells per year in the Little Blue River Basin.

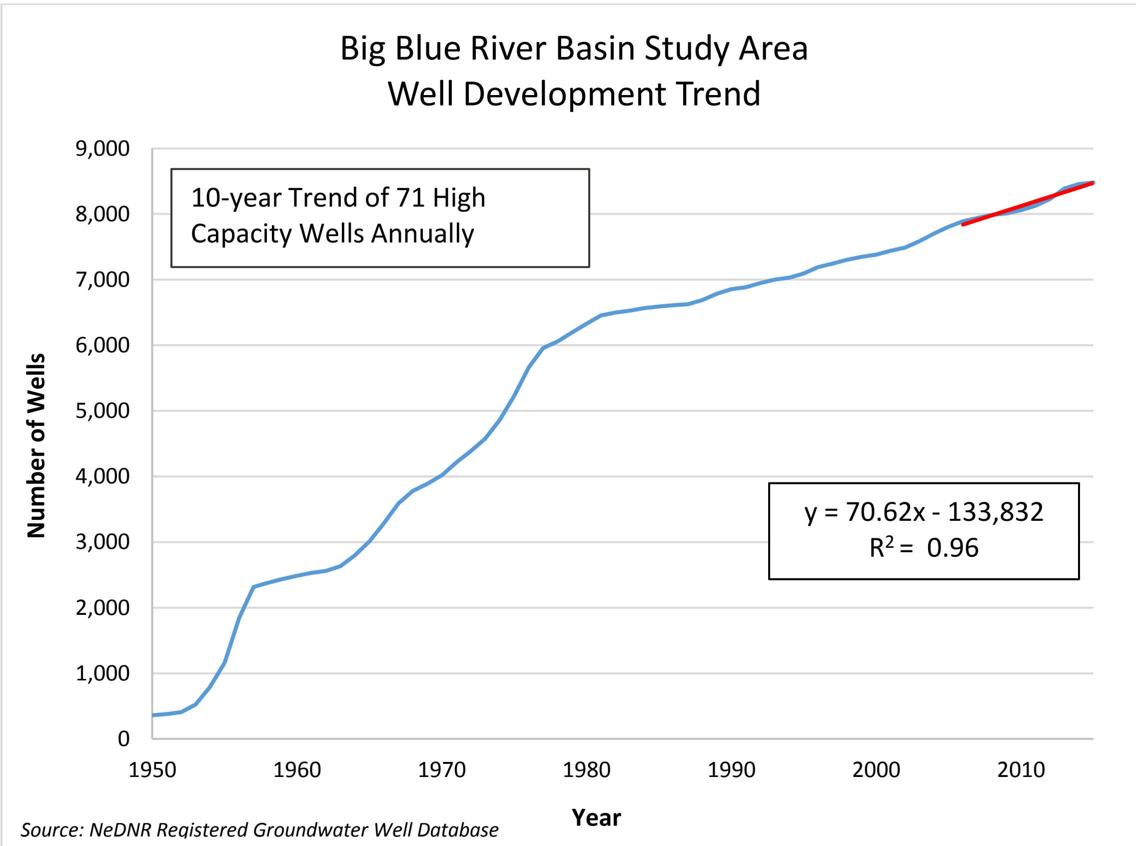

Figure 5-9. High capacity well development, western portion of Big Blue River Basin.

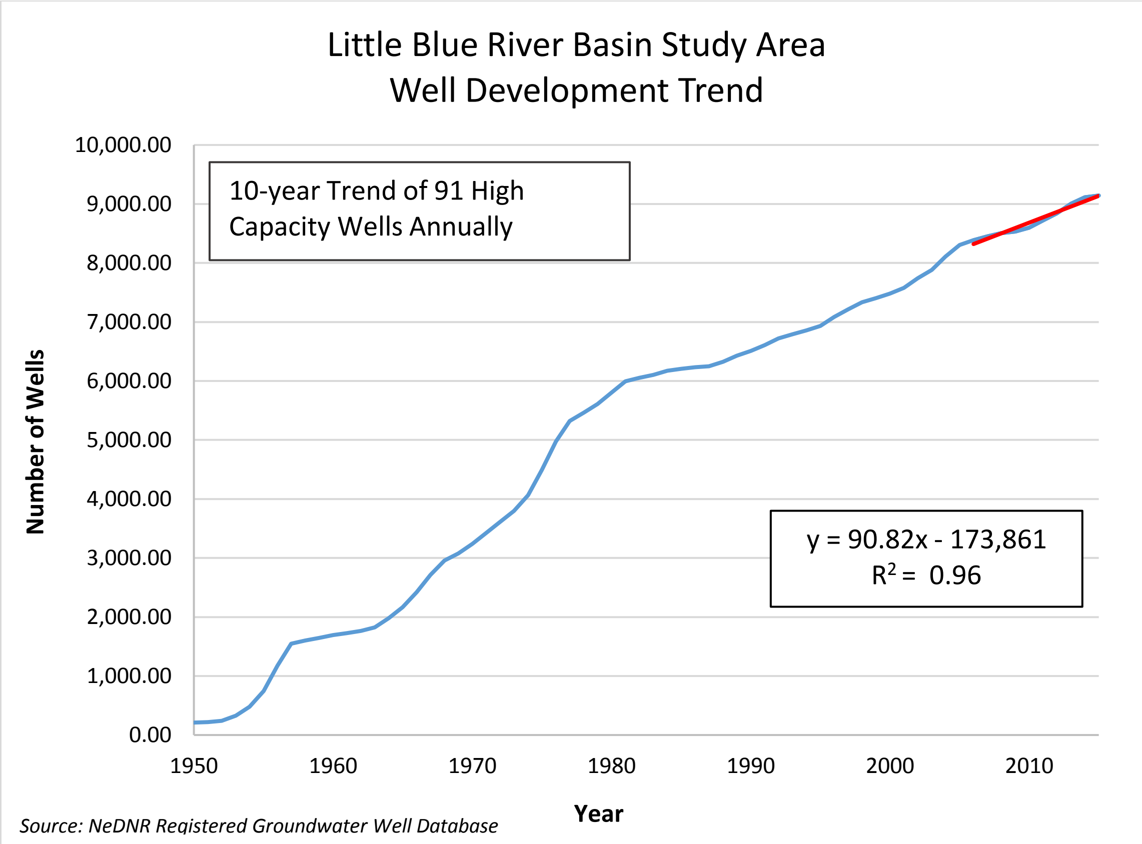

Figure 5-10. High capacity well development, western portion of Little Blue River Basin.

The future depletions due to current and future well development that could be expected to affect streamflow in the basin were estimated using the methodology from Hunt (1999). The results estimate the streamflow in the Big Blue River Basin will be depleted by an additional 3 cfs in 25 years due to potential future development. The results estimate the future streamflow in the Little Blue River Basin will be depleted by an additional 10 cfs in 25 years due to potential future development.

The estimate of the 20-year average number of days surface water is available for diversion with additional future development is calculated by comparing the future lag-adjusted flow with the flows necessary to satisfy the state line compact flow targets. The results of the analyses are shown in Tables 5-11 and 5-12 and are compared to the numbers of days surface water is required to be available to divert 65 percent and 85 percent of the NCCIR in Tables 5-13 and 5-14. The results indicate that, based on current information, the

Department's conclusion that the basin is not fully appropriated would not change if no additional constraints are placed on future development of surface water and groundwater in the basin.

Table 5-11. Estimated number of days surface water is available for diversion in the Big Blue River Basin with current and predicted future development.

Year	July 1 through August 31 Number of Days Surface Water is Available for Diversion	May 1 through September 30 Number of Days Surface Water is Available for Diversion
1	62	153
2	62	153
3	62	153
4	62	153
5	58	149
6	61	152
7	25	116
8	8	96
9	46	137
10	32	123
11	25	116
12	62	153
13	62	153
14	62	153
15	62	153
16	62	153
17	8	67
18	34	112
19	46	137
20	62	153
Average	48.2	136.8

Table 5-12. Estimated number of days surface water is available for diversion in the Little Blue River Basin with current and predicted future development.

Year	July 1 through August 31 Number of Days Surface Water is Available for Diversion	May 1 through September 30 Number of Days Surface Water is Available for Diversion
1	62	153
2	62	153
3	62	153
4	62	153
5	57	132
6	61	152
7	23	99
8	58	142
9	53	120
10	36	117
11	28	117
12	62	153
13	62	153
14	33	122
15	62	153
16	62	153
17	15	76
18	26	85
19	41	131
20	54	122
Average	49.1	132.0

Table 5-13. Comparison between the number of days required to meet the net corn crop irrigation requirement and number of days surface water is available for diversion in the Big Blue River Basin with current and predicted future development.

	Number of Days Necessary to Meet the 65% and 85% of Net Corn Crop Irrigation Requirement	Average Number of Days Available for Diversion with Future Development and 25 Years of Lag Impacts
July 1 – August 31 (65% Requirement)	23.9	48.2 (24.3 days above the requirement)
May 1 – September 30 (85% Requirement)	31.3	136.8 (105.5 days above the requirement)

Table 5-14. Comparison between the number of days required to meet the net corn crop irrigation requirement and number of days surface water is available for diversion in the Little Blue River Basin with current and predicted future development.

	Number of Days Necessary to Meet the 65% and 85% of Net Corn Crop Irrigation Requirement	Average Number of Days Available for Diversion with Future Development and 25 Years of Lag Impacts
July 1 – August 31 (65% Requirement)	25.7	49.1 (23.4 days above the requirement)
May 1 – September 30 (85% Requirement)	33.6	132.0 (98.4 days above the requirement)

5.9 Sufficiency to Avoid Noncompliance

The State of Nebraska is a signatory member of the Kansas–Nebraska Big Blue River Compact (Compact). The purposes of the Compact are to promote interstate comity, to achieve an equitable apportionment of the waters of the Big Blue River Basin, to encourage continuation of the active pollution-abatement programs in each of the two states, and to seek further reduction in pollution of the waters of the Big Blue River Basin.

The Compact sets state line flow targets from May 1 through September 30. The state line targets measured in cubic feet of water per second (cfs) are shown in Table 5-15. If the flow targets are not met, then the State of Nebraska is required to take the following actions:

1. Limit surface water diversions by natural flow appropriators to their decreed appropriations;
2. Close natural flow appropriators with priority dates junior to November 1, 1968, in accordance with the doctrine of priority;
3. Ensure that no illegal surface water diversions are taking place; and
4. Regulate wells installed after November 1, 1968 within the alluvium and valley side terrace deposits downstream of Turkey Creek in the Big Blue River Basin and downstream of Walnut Creek in the Little Blue River Basin, unless the Compact Administration determines that such regulation would not yield any measurable increase in flows at the state line gage.

For the present time, the Compact Administration has found that the regulation of wells within the area described in number four above will not yield measurable increases in flow at the state line.

Table 5-15. State line flow targets for the Blue River Basins.

Month	Big Blue River Target Flow	Little Blue River Target Flow
May	45 cfs	45 cfs
June	45 cfs	45 cfs
July	80 cfs	75 cfs
August	90 cfs	80 cfs
September	65 cfs	60 cfs

As long as Nebraska administers surface and groundwater in compliance with the Compact, decreased streamflow, in and of itself, will not cause Nebraska to be in noncompliance; therefore, any depletion would not cause Nebraska to be in noncompliance. Decreased streamflows could, however, increase the number of times the state would have to administer water to remain in compliance, thereby reducing the number of days available for junior irrigators to divert.

5.10 Groundwater Recharge Sufficiency

The streamflow is sufficient to sustain over the long-term the beneficial uses from wells constructed in aquifers dependent on recharge from the stream as explained in Appendix F.

5.11 Current Studies Being Conducted to Assist with Future Analysis

The Department has completed a numerical model for the Blue River Basins. The Department plans to continue to work with the local NRDs in these basins to refine pumping estimates that are incorporated into the model for further refinement of the model. Additionally, the Little Blue and Tri-Basin NRDs are each in developmental phases of their voluntary integrated management plans, with the planning and stakeholder processes underway. The Lower Big Blue NRD has initiated an interest to the Department to develop a voluntary integrated management plan for the Big Blue River Basin.

5.12 Relevant Data Provided by Interested Parties

The Department published a request for relevant data from interested parties for this year's evaluation on November 23, 2016 (see Appendix B for affidavit). The Department did not receive any such information.

5.13 Conclusions

Based on the analysis of the sufficiency of the long-term surface water supply in the Blue River Basins, the Department has reached a preliminary conclusion that the basins are not fully appropriated. The Department has also determined that, based on current information, if no additional legal constraints are imposed on future development of hydrologically connected surface water and groundwater, and reasonable projections are made about the extent and location of future development, this preliminary conclusion would not change to a conclusion that the basin is fully appropriated.

The analysis of lag effects of current development for areas in the Big Blue River Basin indicates a reduction in streamflows of 12 cfs in 25 years. The analysis of lag effects of current development for areas in the Little Blue River Basin indicates a reduction in streamflows of 17 cfs in 25 years.

The analysis of the impacts of potential future development in the Big Blue River Basin based on current development trends indicates an additional reduction in streamflows of 3 cfs in 25 years. The analysis of the impacts of potential future development in the Little Blue River Basin based on current development trends indicates an additional reduction in streamflows of 10 cfs in 25 years.

Bibliography of Hydrogeologic References for Big and Little Blue River Basins

Conservation and Survey Division. 2005. *Mapping of Aquifer Properties-Transmissivity and Specific Yield-for Selected River Basins in Central and Eastern Nebraska.* Lincoln.

Hunt, B. 1999. Unsteady Stream Depletion from Ground Water Pumping, *Ground Water*, 37(1): 98-102.

Nebraska Department of Natural Resources. 2005. *2006 Annual Evaluation of Availability of Hydrologically Connected Water Supplies*. Lincoln.

Nebraska Department of Natural Resources. 2013. *Ground Water Model for the Big Blue and Little Blue River Basins*. Lincoln.

Wen, F.J. and X.H. Chen, 2006. Evaluation of the Impact of Groundwater Irrigation on Streamflow Depletion in Nebraska. *Journal of Hydrology,* 327: 603-617.

6.0 LOWER NIOBRARA RIVER BASIN

6.1 Summary

Based on the analysis of the sufficiency of the long-term surface water supply in the Lower Niobrara River Basin, the Department has reached a preliminary conclusion that the basin is not fully appropriated. The Department has also determined that, based on current information, if no additional legal constraints are imposed on future development of hydrologically connected surface water and groundwater, and reasonable projections are made about the extent and location of future development, this preliminary conclusion would not change to a conclusion that the basin is fully appropriated.

The analysis of lag effects of current development for areas in the Lower Niobrara River Basin indicates a reduction in streamflows by 29 cfs in 25 years. The analysis of the impacts of potential future development in the Lower Niobrara River Basin, based on current development trends, indicates an additional reduction in streamflows of 84 cfs in 25 years.

6.2 Basin Description

The Lower Niobrara River Basin in Nebraska is defined in this report as the surface areas in Nebraska that drain into the Niobrara River Basin downstream of those portions of the basin which were designated as fully appropriated in 2004. This general basin area extends from the Mirage Flats diversion dam in the west downstream to the confluence of the Niobrara River and the Missouri River and includes all aquifers that impact surface water flows in the basin (Figure 6-1). The total area of the Lower Niobrara River Basin evaluated in this year’s report is approximately 12,100 square miles. NRDs with significant area in the basin are the Upper Niobrara-White, the Middle Niobrara, and the Lower Niobrara NRDs.

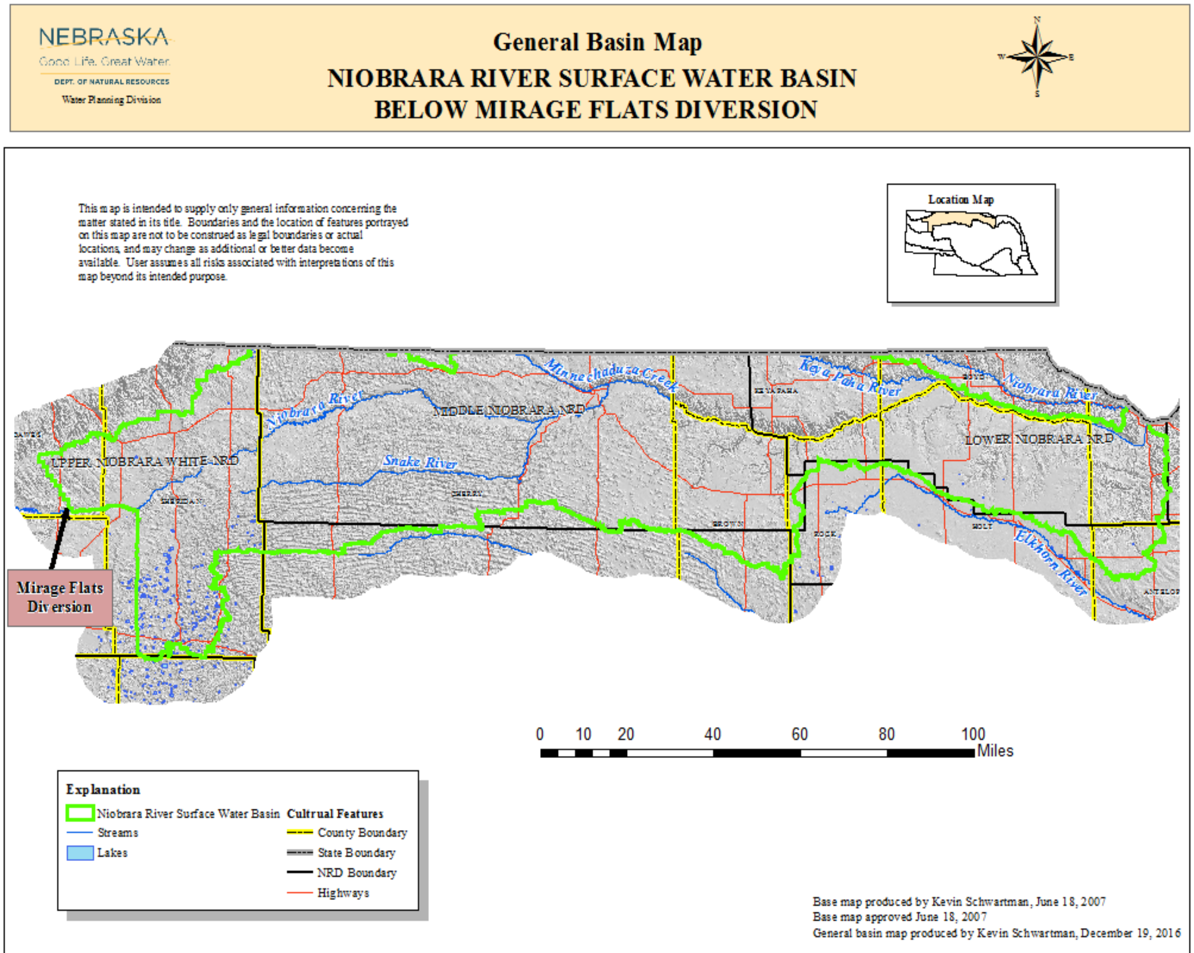

Figure 6-1. General basin map, Lower Niobrara River Basin.

6.3 Nature and Extent of Water Use

6.3.1 Groundwater

Groundwater in the Lower Niobrara River Basin is used for a variety of purposes: domestic, industrial, livestock, irrigation, and other uses. A total of 9,390 groundwater wells had been registered within the basin as of December 31, 2015 (Department registered groundwater wells database) (Figure 6-2). The locations of all active groundwater wells can be seen in Figure 6-3.

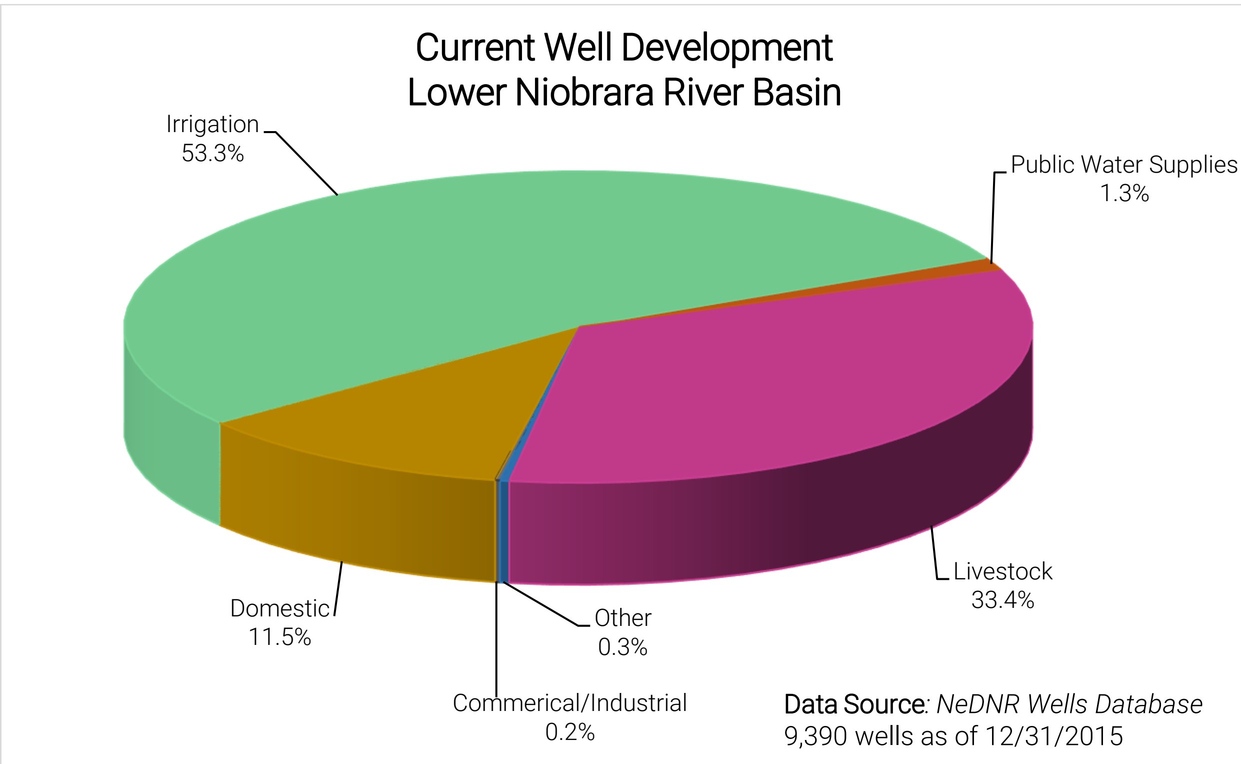

Figure 6-2. Current well development by number of registered wells, Lower Niobrara River Basin.

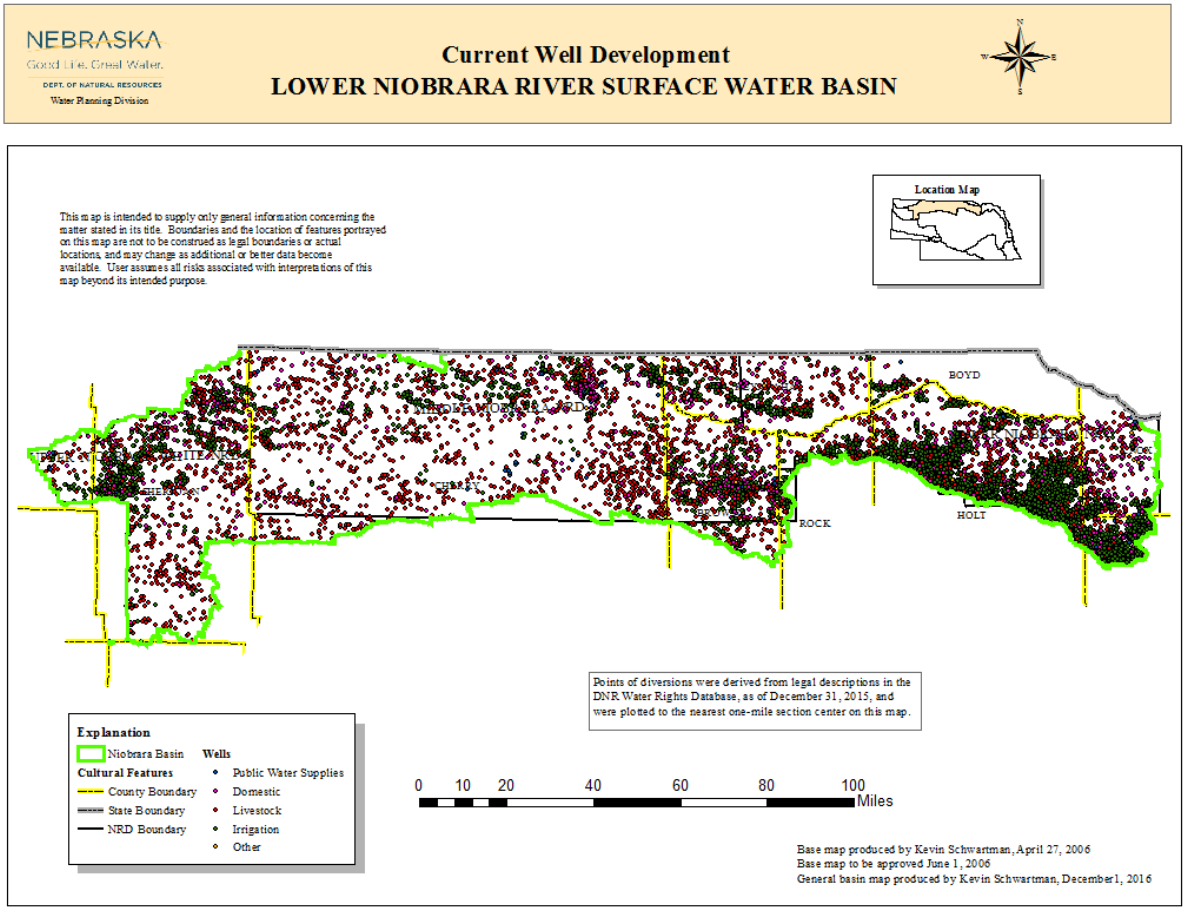

Figure 6-3. Current well locations, Lower Niobrara River Basin.

6.3.2 Surface Water

As of December 31, 2015, 757 active surface water appropriations were held in the Lower Niobrara River Basin, issued for a variety of uses (Figure 6-4). Most of the surface water appropriations are for irrigation use and storage and tend to be located on the major streams. The first surface water appropriations in the basin were permitted in 1894 and development has continued through the present day. The approximate locations of the surface water diversion points are shown in Figure 6-5.

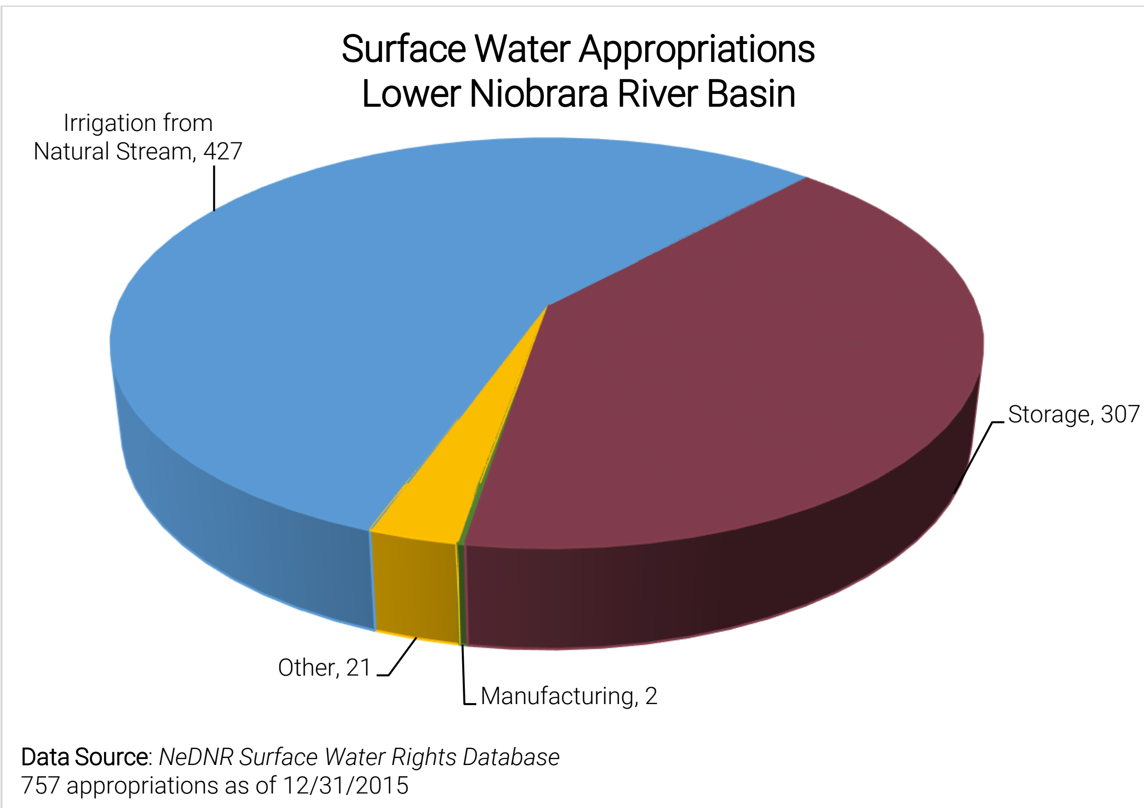

Figure 6-4. Surface water appropriations by number of diversion points, Lower Niobrara River Basin.

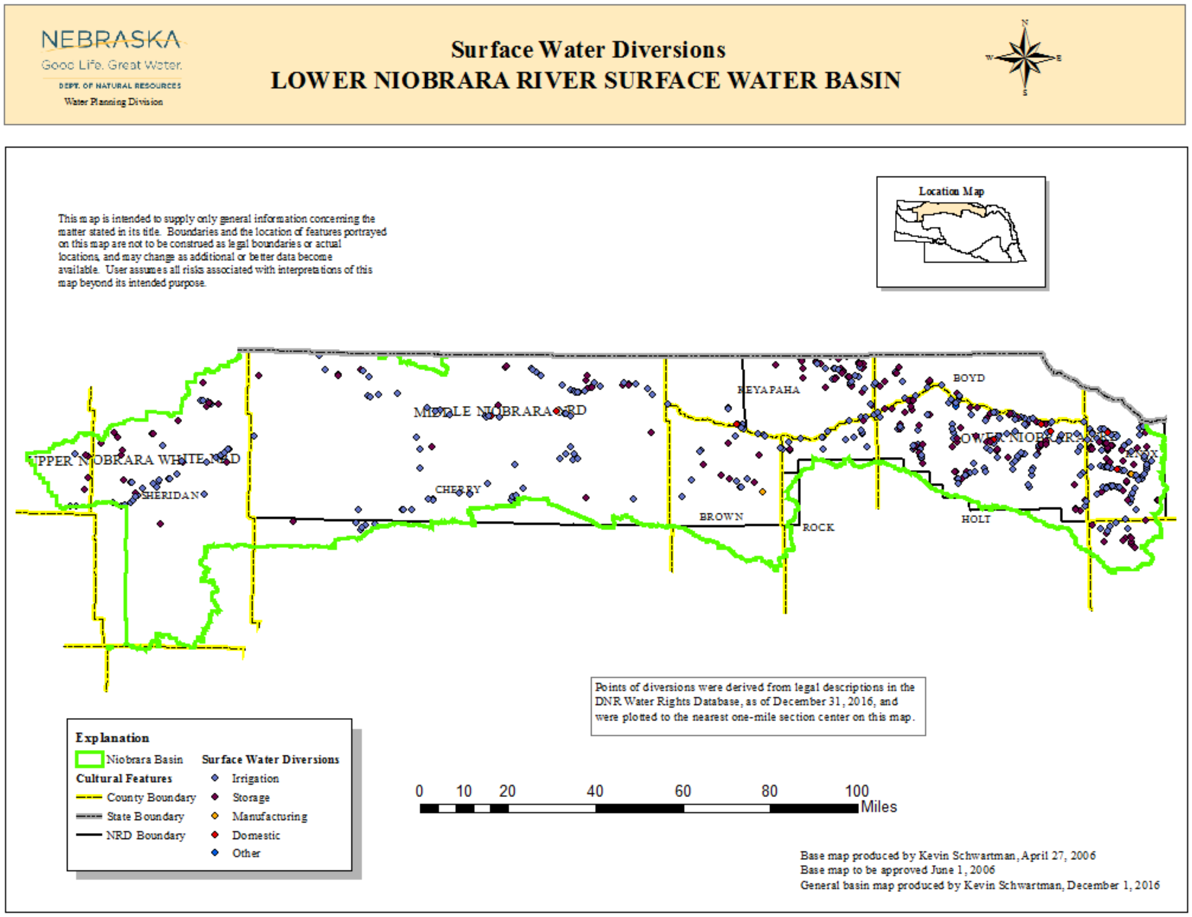

Figure 6-5. Surface water appropriation diversion locations, Lower Niobrara River Basin.

6.4 Hydrologically Connected Area

The CENEB model and Upper Niobrara-White model were used to determine the extent of the 10/50 area for the Lower Niobrara River Basin. Figure 6-6 specifies the extent of the 10/50 area.

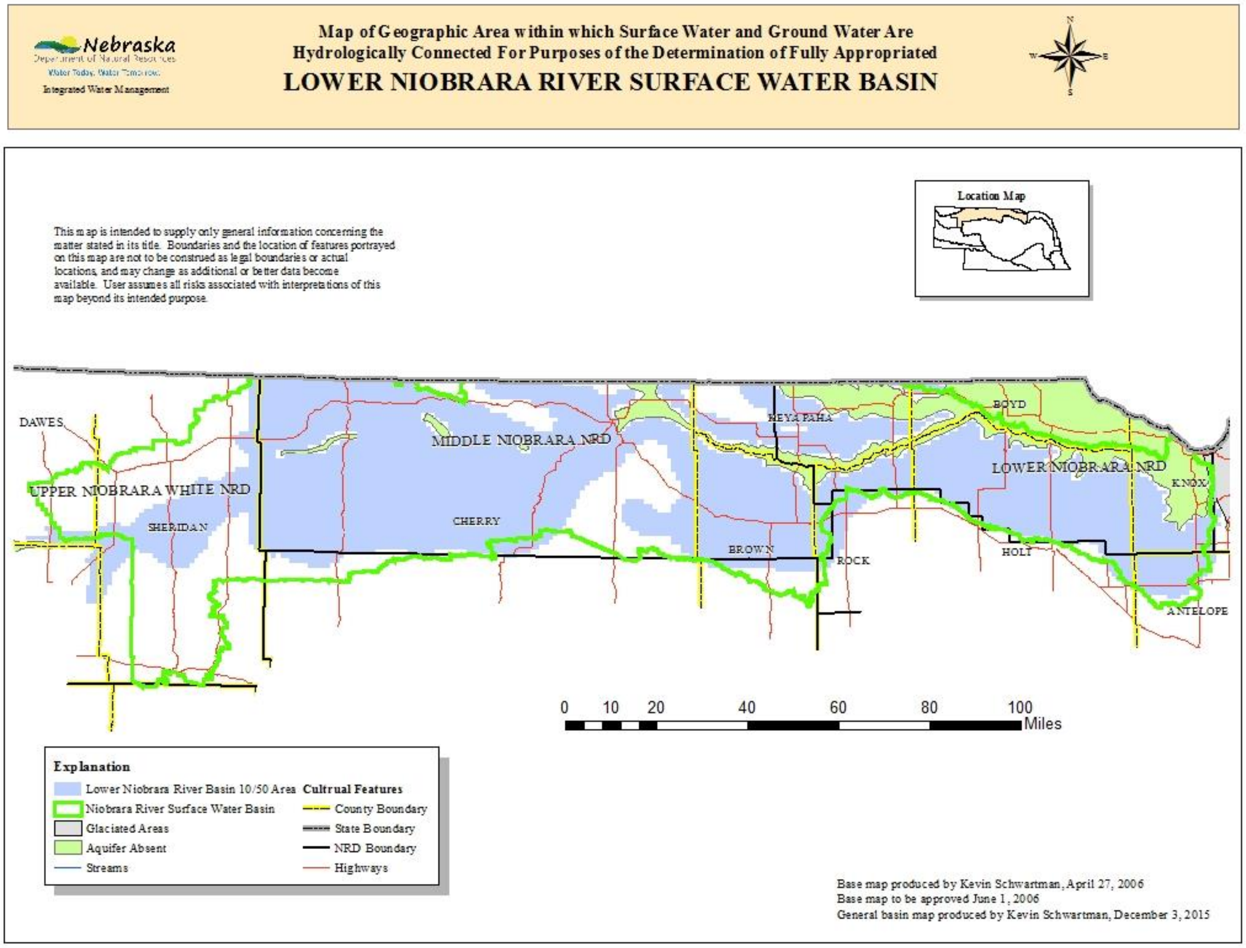

Figure 6-6. 10/50 area, Lower Niobrara River Basin.

6.5 Net Corn Crop Irrigation Requirement

Figure 6-7 is a map of the net corn crop irrigation requirement (NCCIR) for the Lower Niobrara River Basin (DNR, 2005). The NCCIR in the basin ranges from 8.9 to 13.9 inches. To assess the number of days required to be available for diversion, a surface water diversion rate equal to 1 cfs per 70 acres, a downtime of 10 percent, and an irrigation efficiency of 80 percent were assumed. Based on these assumptions, a junior surface water appropriation in the Lower Niobrara River Basin will require between 23.6 and 36.9 days annually to divert 65 percent of the NCCIR and between 30.9 and 48.3 days to divert 85 percent of the NCCIR.

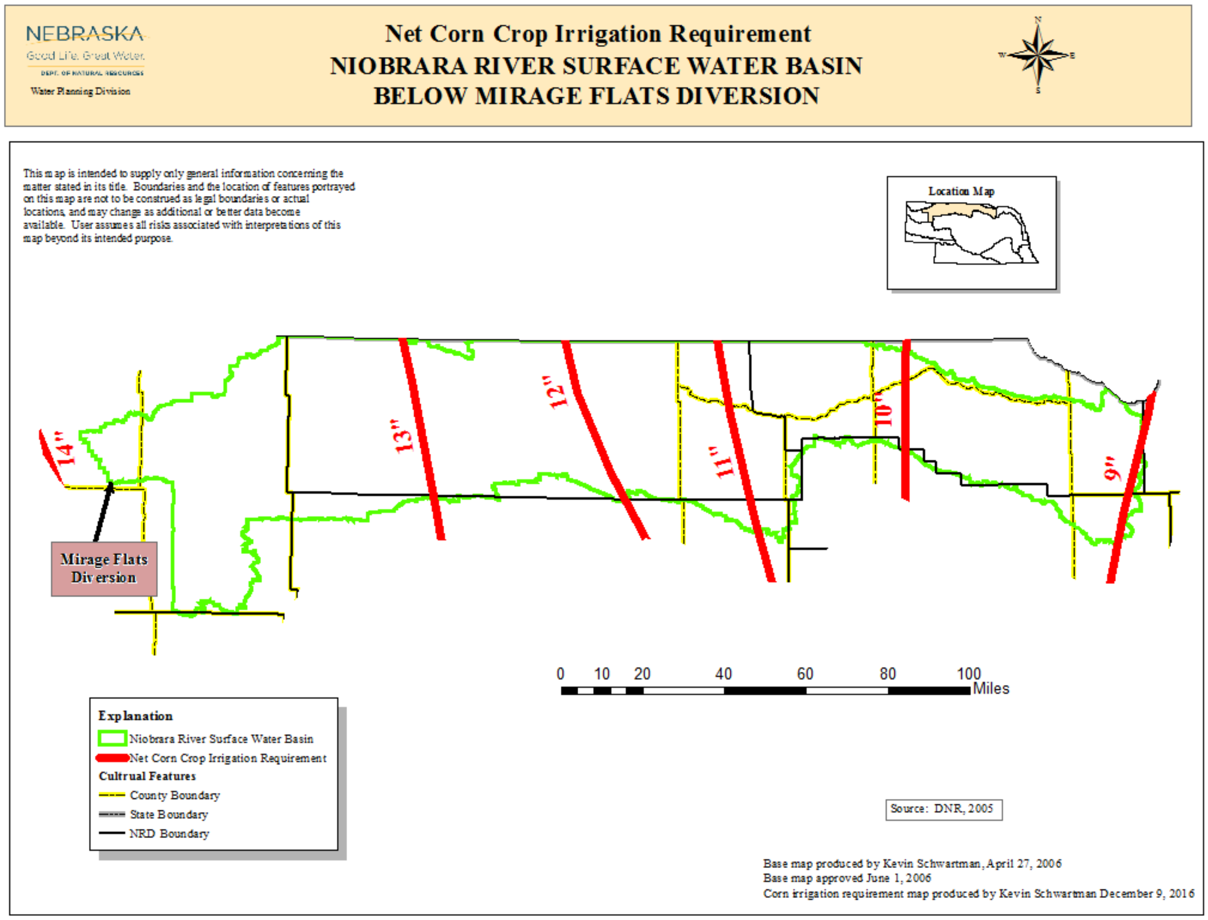

Figure 6-7. Net corn crop irrigation requirement (NCCIR), Lower Niobrara River Basin.

6.6 Surface Water Closing Records

Table 6-1 contains records of all surface water administration that has occurred in the Lower Niobrara River Basin between 1996 and 2015.

Table 6-1. Surface water administration in the Lower Niobrara River Basin, 1996-2015.

Year	Water Body	Days	Closing Date	Opening Date
2007	Niobrara River above Spencer Hydro	6	May 1	May 7
2007	Niobrara River above Spencer Hydro	61	Aug 1	Oct 1
2008	Niobrara River above Spencer Hydro	124	May 1	Oct 6
2009	Niobrara River above Spencer Hydro	8	May 19	May 27
2009	Niobrara River above Spencer Hydro	14	Jun 2	Jun 16
2009	Niobrara River above Spencer Hydro	15	Jul 2	Jul 17
2009	Niobrara River above Spencer Hydro	75	Jul 22	Oct 5
2010	Niobrara River above Spencer Hydro	35	Aug 20	Sep 24
2011	Niobrara River above Spencer Hydro	7	May 10	May 17
2011	Niobrara River above Spencer Hydro	34	Jul 21	Aug 24
2011	Niobrara River above Spencer Hydro	37	Sep 2	Oct 8
2012	Niobrara River above Spencer Hydro	114	May 15	Sep 6
2012	North Branch Verdigre Creek	38	Jul 13	Aug 20
2013	Niobrara River above Spencer Hydro	7	Jul 31	Aug 7
2013	Niobrara River above Spencer Hydro	61	Aug 14	Oct 14
2014	Niobrara River above Spencer Hydro	90	Jul 9	Oct 7
2015	Niobrara River above Spencer Hydro	67	Jul 16	Sep 21

6.7 Evaluation of Current Development

6.7.1 Current Water Supply

The current water supply is estimated by using the most recent 20-year period (1996-2015) of flows available for junior irrigation rights. The results of the analysis conducted for the Lower Niobrara River Basin are shown in Table 6-2. The results indicate that the current surface water supply in the basin provides an average of at least 43.0 days available for diversion between July 1 and August 31 and 115.5 days available for diversion between May 1 and September 30 (Table 6-3).

Table 6-2. Estimate of the current number of days surface water is available for diversion in the Lower Niobrara River Basin.

Year	July 1 through August 31 Number of Days Surface Water is Available for Diversion	May 1 through September 30 Number of Days Surface Water is Available for Diversion
1996	62	153
1997	62	153
1998	62	153
1999	62	153
2000	62	153
2001	62	153
2002	62	153
2003	62	153
2004	62	153
2005	62	153
2006	62	153
2007	31	86
2008	0	0
2009	7	46
2010	51	118
2011	28	84
2012	0	39
2013	37	98
2014	9	70
2015	15	86
Average	43.0	115.5

Table 6-3. Comparison between the number of days required to meet the net corn crop irrigation requirement and the current number of days surface water is available for diversion in the Lower Niobrara River Basin.

	Number of Days Necessary to Meet the 65% and 85% of Net Corn Crop Irrigation Requirement	Average Number of Days Available for Diversion with Current Development
July 1 – August 31 (65% Requirement)	23.6 to 36.9	43.0 (at least 6.1 days above the requirement)
May 1 – September 30 (85% Requirement)	30.9 to 48.3	115.5 (at least 67.2 days above the requirement)

6.7.2 Long-Term Water Supply

In order to complete the long-term evaluation of surface water supplies, a future 20-year water supply for each basin must be estimated. The Lower Niobrara River Basin's major water sources are precipitation, which runs off as direct streamflow and infiltrates into the ground to discharge as baseflow; groundwater movement into the basin, which discharges as baseflow; and streamflow from the upper Niobrara River. Using methodology published in the *Journal of Hydrology* (Wen and Chen 2005), a nonparametric Mann-Kendall trend test of the weighted average precipitation in the basin was completed. The analysis showed no statistically significant trend in precipitation ($P > 0.95$) over the past 60 years (Figure 6-8). Therefore, using the previous 20 years of precipitation and streamflow data as the best estimate of the future surface water supply is a reasonable starting point for applying the lag depletions from groundwater wells.

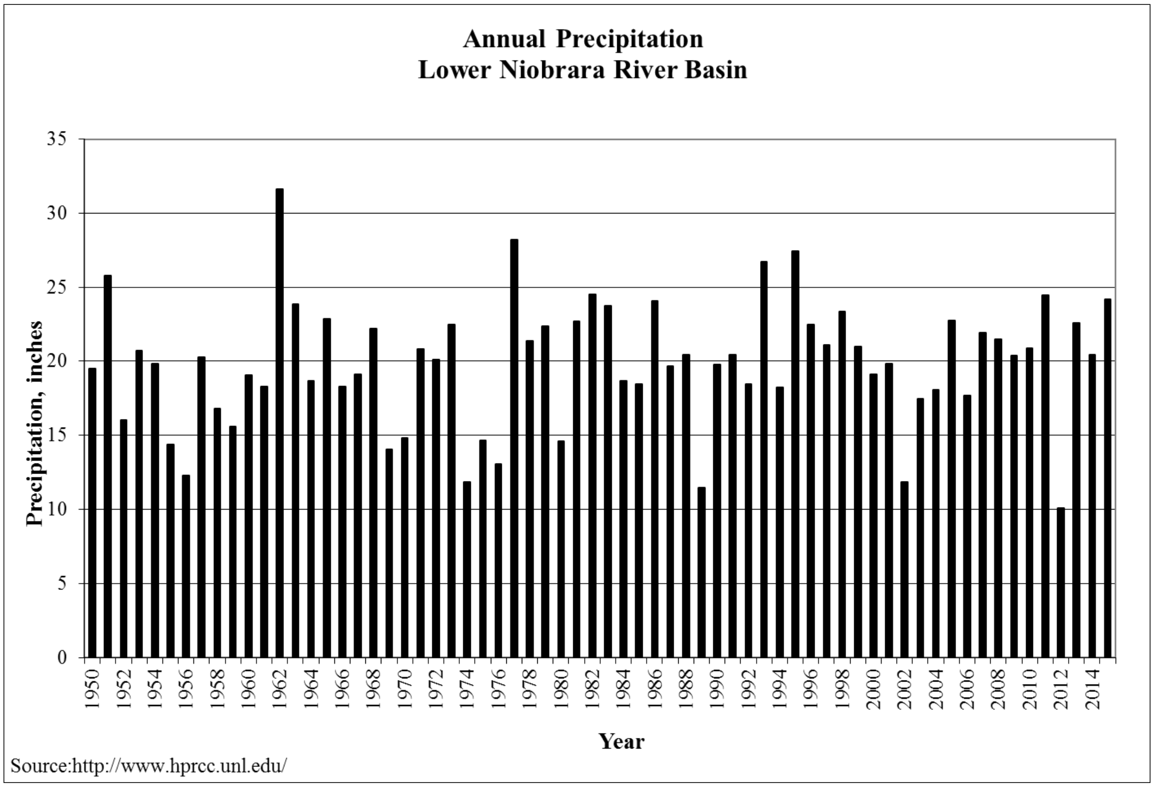

Figure 6-8. Annual precipitation, Lower Niobrara River Basin.

6.7.3 Depletions Analysis

The future depletions due to current well development that could be expected to affect streamflow in the basin were estimated using the CENEB Model. The results estimate the future streamflows in the Lower Niobrara River Basin to be depleted by an additional 29 cfs in 25 years.

6.7.4 Evaluation of Current Levels of Development against Future Water Supplies

The estimates of the 20-year average number of days available for diversion are calculated by comparing the depleted future streamflows with the flows necessary to satisfy the Spencer Hydropower right during the period that water administration has historically occurred (2007-2015). The results of the analyses are shown in Table 6-4 and are compared to the numbers of days surface water is required to be available to divert

65 percent and 85 percent of the NCCIR in Table 6-5. The estimated long-term surface water supply, given current levels of development, is sufficient to satisfy the 65/85 rule.

Table 6-4. Estimate of days surface water is available for diversion in the Lower Niobrara River Basin with current development and 25-year lag impacts.

Year	July 1 through August 31 Number of Days Surface Water is Available for Diversion	May 1 through September 30 Number of Days Surface Water is Available for Diversion
1	62	153
2	62	152
3	62	153
4	62	153
5	62	153
6	62	153
7	62	152
8	62	153
9	62	153
10	62	153
11	62	153
12	31	86
13	0	0
14	7	45
15	50	117
16	28	84
17	0	39
18	37	95
19	9	68
20	14	85
Average	42.9	115.0

Table 6-5. Comparison between the number of days required to meet the net corn crop irrigation requirement and number of days surface water is available for diversion in the Lower Niobrara River Basin with current development and lag impacts.

	Number of Days Necessary to Meet the 65% and 85% of Net Corn Crop Irrigation Requirement	Average Number of Days Available for Diversion with Future Development and 25 Years of Lag Impacts
July 1 – August 31 (65% Requirement)	23.6 to 36.9	42.9 (6.0 days above the requirement)
May 1 – September 30 (85% Requirement)	30.9 to 48.3	115.0 (66.7 days above the requirement)

6.8 Evaluation of Predicted Future Development

Estimates of the number of high-capacity wells (wells pumping greater than 50 gpm) that would be completed over the next 25 years, if no new legal constraints on the construction of such wells were imposed, were calculated based on extrapolating the present-day rate of increase in well development into the future (Figures 6-9). The present-day rate of development is based on the linear trend of the previous 10 years of development in the basins. Based on the analysis of the past 10 years of development, the rate of increase in high-capacity wells is estimated to be 135 wells per year in the Lower Niobrara River Basin. This rate does not reflect all of the current limits on new wells that are currently in place within the basin.

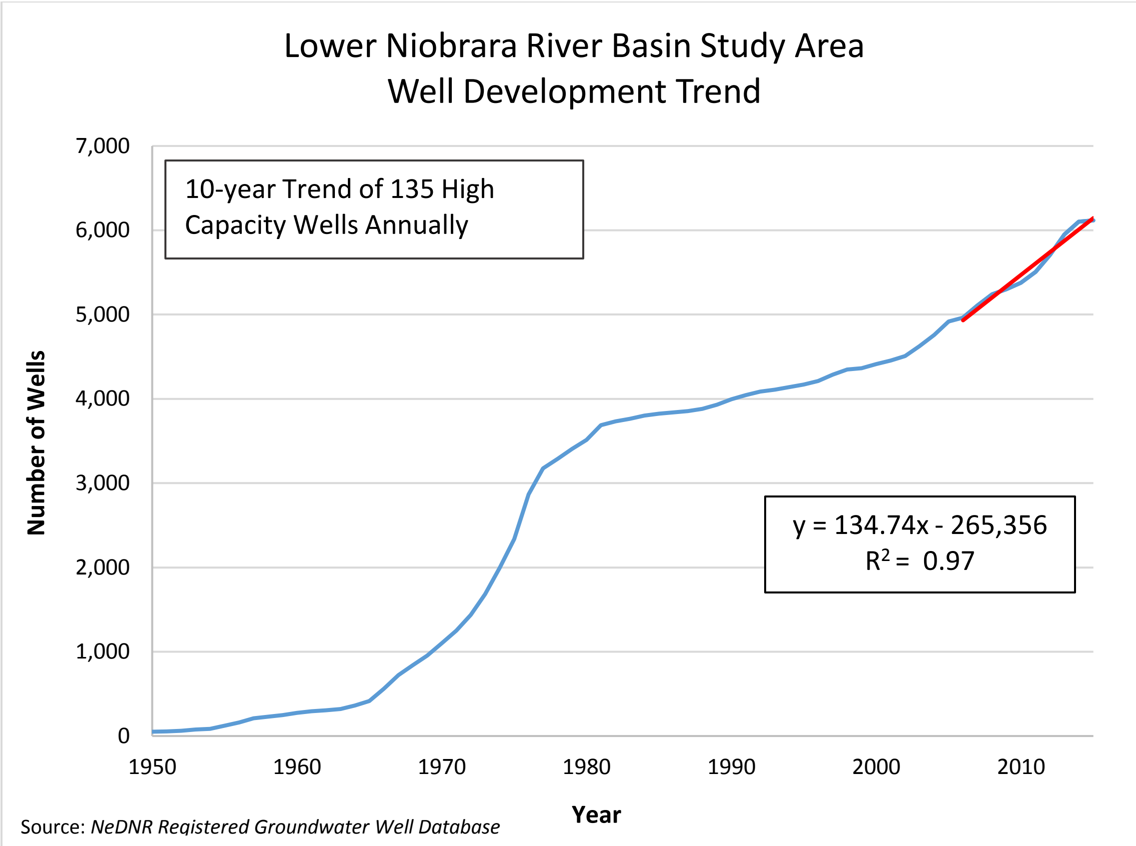

Figure 6-9. High capacity well development in the Lower Niobrara River Basin.

The future depletions due to current and future well development that could be expected to affect streamflow in the basin were estimated using the CENEB model. The results estimate the streamflow in the Lower Niobrara River Basin will be depleted by an additional 84 cfs in 25 years due to this estimate of future development.

The estimate of the 20-year average number of days surface water is available for diversion with additional future development is calculated by comparing the depleted future streamflows with the flows necessary to satisfy the Spencer Hydropower right during the period that water administration has historically occurred (2007-2015). The results of the analyses are shown in Table 6-6 and are compared to the numbers of days surface water is required to be available to divert 65 percent and 85 percent of the NCCIR in Table 6-7. The estimated long-term surface water supply, given this projected level of development, is sufficient to satisfy the 65/85 rule. The results indicate that, based on current information, the Department's conclusion that the basin is not fully appropriated would not change if no additional constraints are placed on future development of surface water and groundwater in the basin.

Table 6-6. Estimated number of days surface water is available for diversion in the Lower Niobrara River Basin with current and predicted future development.

Year	July 1 through August 31 Number of Days Surface Water is Available for Diversion	May 1 through September 30 Number of Days Surface Water is Available for Diversion
1	62	145
2	62	147
3	62	148
4	61	149
5	62	152
6	62	149
7	62	151
8	62	153
9	62	153
10	62	151
11	62	153
12	31	83
13	0	0
14	6	37
15	49	110
16	28	79
17	0	37
18	37	94
19	9	64
20	13	82
Average	42.7	111.9

Table 6-7. Comparison between the number of days required to meet the net corn crop irrigation requirement and number of days surface water is available for diversion in the Lower Niobrara River Basin with current and predicted future development.

	Number of Days Necessary to Meet the 65% and 85% of Net Corn Crop Irrigation Requirement	Average Number of Days Available for Diversion with Future Development and 25 Years of Lag Impacts
July 1 – August 31 (65% Requirement)	23.6 to 36.9	42.7 (5.8 days above the requirement)
May 1 – September 30 (85% Requirement)	30.9 to 48.3	111.9 (63.6 days above the requirement)

6.9 Instream Flow Surface Water Appropriation Analysis

The Nebraska Game and Parks Commission's holds two instream flow rights within the Lower Niobrara River Basin. These two rights are located on Long Pine Creek. The purpose of these rights is to maintain habitat for the fish community. Therefore, the Department determined that an appropriate standard of interference would be to determine whether the instream flow requirements that could be met at the time the water rights were granted can still be met today.

To calculate the average monthly flow that the instream flow permits could have expected at the time they were granted, the 20-year period prior to the permits being granted (1969-1988) was used. In conducting this analysis, the lag impacts were calculated for development through 1988 and subtracted from the daily flows (see Section 4.2.4 for more detail). The average number of days that flows were available for each month at the time the appropriations were obtained and compared against the current average number of days that flows are available for each month. The results are shown in Table 6-8.

The results in Table 6-8 indicate that the instream flow appropriation is not expected to experience erosion of the water right for any month. Thus, the long-term surface water supply estimate in the basin is sufficient for the instream flow appropriations in the basin, based on the current level of development and the calculated 25 year lag impacts.

Table 6-8. Number of days Long Pine Creek instream flow appropriation is expected to be met.

Month	Number of Days Flows Met at Time of Application [1]	Number of Days Flows Met With Current Development [2]	Difference in the Number of Days Instream Flow Appropriation is Currently Met
October	31.0	31.0	0
November	30.0	30.0	0
December	31.0	31.0	0
January	31.0	31.0	0
February	28.3	28.3	0
March	31.0	31.0	0
April	30.0	30.0	0
May	31.0	31.0	0
June	30.0	30.0	0
July	31.0	31.0	0
August	31.0	31.0	0
September	30.0	30.0	0

[1] The number of days instream flows would be expected to be met at the time of application (1969-1988) with lag effects of well development at the time of the appropriation.
[2] The number of days instream flows would be expected to be met at current time (1996-2015) with lag effects of current well development.

6.10 Sufficiency to Avoid Noncompliance

There are no compacts on any portions of the Lower Niobrara River Basin in Nebraska.

6.11 Groundwater Recharge Sufficiency

The streamflow is sufficient to sustain over the long-term the beneficial uses from wells constructed in aquifers dependent on recharge from the stream, as explained in Appendix F.

6.12 Current Studies Being Conducted to Assist with Future Analysis

The Department and NRDs with areas hydrologically connected to streams within the basin are currently working to develop a basin-wide plan for integrated management of the water resources within the basin. Additionally, the Lower Niobrara NRD has completed a voluntary integrated management plan and the Middle Niobrara NRD is currently working with the Department to develop an integrated management plan. The Upper Niobrara-White NRD completed an integrated management plan for the fully appropriated portions of the District in 2009.

To assess water resources in the Upper Niobrara White NRD, the Department and NRD are working together on various types of analysis to better determine the future long term condition of groundwater and baseflow in the area utilizing the Department's Conjunctive Use Model.

6.13 Relevant Data Provided by Interested Parties

The Department published a request for relevant data from interested parties for this year's evaluation on November 23, 2016 (see Appendix B for affidavit). The Department did not receive any such information.

6.14 Conclusions

Based on the analysis of the sufficiency of the long-term surface water supply in the Lower Niobrara River Basin, the Department has reached a preliminary conclusion that the basin is not fully appropriated under the current rule. The Department has also determined that, based on current information, if no additional legal constraints are imposed on future development of hydrologically connected surface water and groundwater, and reasonable projections are made about the extent and location of future development, this preliminary conclusion would not change to a conclusion that the basin is fully appropriated.

The analysis of lag effects of current development for areas in the Lower Niobrara River Basin indicates a reduction in streamflows of 29 cfs in 25 years. The analysis of the impacts of potential future development in the Lower Niobrara River Basin based on current development trends indicates an additional reduction in streamflows of 84 cfs in 25 years.

Although the basin has not been be determined to be fully appropriated using the methodology of the current rule, there may be times when supplies within the basin or a particular subbasin are not sufficient to meet all demands in that basin or subbasin, as is shown by the Department's INSIGHT analysis. This is important for water managers to consider when developing a basin-wide plan or voluntary integrated management plan.

Bibliography of Hydrogeologic References for Lower Niobrara River Basin

Conservation and Survey Division. 2005. *Mapping of Aquifer Properties-Transmissivity and Specific Yield-for Selected River Basins in Central and Eastern Nebraska.* Lincoln.

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Nebraska Department of Natural Resources. 2013. *Central Nebraska Groundwater Flow Model*. Lincoln.

Nebraska Department of Natural Resources. 2014. *Upper Niobrara-White Groundwater Model*. Lincoln.

Wen, F.J. and X.H. Chen, 2006. Evaluation of the Impact of Groundwater Irrigation on Streamflow Depletion in Nebraska. *Journal of Hydrology,* 327: 603-617.

7.0 LOWER PLATTE RIVER BASIN

7.1 Summary

Based on the analysis of the sufficiency of the long-term surface water supply in the Lower Platte River Basin, the Department has reached a conclusion that the basin is not fully appropriated under the current rule. The analysis of the lag effects from current development on the Lower Platte River Basin indicates a reduction in streamflows upstream of Louisville of 337 cfs, approximately 35 cfs of which occurs due to lag impacts upstream of North Bend. The analysis of lag impacts of future development on the Lower Platte River Basin based on current development trends indicates an additional reduction in streamflows upstream of Louisville of 122 cfs in 25 years, approximately 71 cfs of which occurs due to development upstream of North Bend. The analysis of future water supplies in the Lower Platte River Basin indicates that, if no additional constraints are placed on groundwater and surface water development, and reasonable projections are made of the extent of future development, then the effects on the long-term water supply would not cause the basin to become fully appropriated in the future.

7.2 Basin Description

The Lower Platte River is defined as the reach of the Platte River from its confluence with the Loup River to its confluence with the Missouri River. The Lower Platte River Basin is defined as all surface areas that drain into the Lower Platte River, including those areas that drain into the Loup River and the Elkhorn River, and all aquifers that impact surface water flows of the basin (Figure 7-1). The total area of the Lower Platte River surface water basin is approximately 25,400 square miles, of which approximately 15,200 square miles are in the Loup River subbasin and approximately 7,000 square miles are in the Elkhorn River subbasin. NRDs with significant area in the basin are the Lower Platte South, the Lower Platte North, the Upper Elkhorn, the Lower Elkhorn, the Upper Loup, the Lower Loup, and the Papio-Missouri River NRDs.

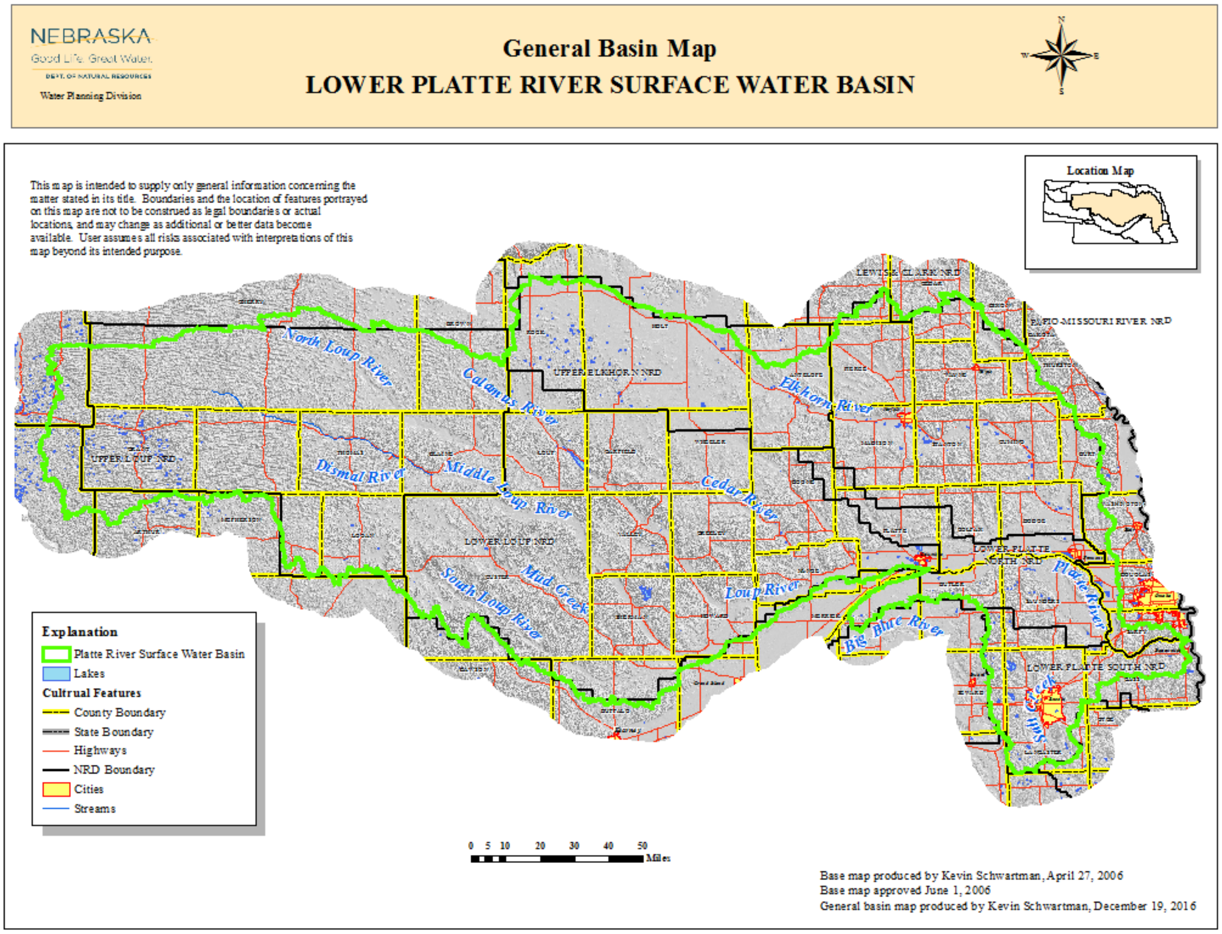

Figure 7-1. General basin map, Lower Platte River Basin.

7.3 Subbasin Relationships

When considering the Lower Platte River Basin, it is important to understand the relationship between the senior surface water appropriations and the junior surface water appropriations in the Loup and Elkhorn River subbasins with regard to appropriations in the downstream portion of the Lower Platte River Basin. In general, when a senior water right calls for water, all water rights upstream of the senior right will be shut off in order to get water to the senior appropriator. Starting with the most junior appropriators, the Department will shut off as many junior appropriators as necessary to provide water to the senior appropriator. For senior appropriations along the Lower Platte River, this includes junior appropriators in the Loup and Elkhorn River subbasins, because those subbasins provide flows to the reaches of the Lower Platte River that require administration for senior appropriators.

The senior appropriations for which water is administered in the Lower Platte River Basin are the instream flow rights. The instream flow rights have a priority date of November 30, 1993, and, when these appropriations are not being fulfilled, all surface water appropriations junior to that priority date will be closed. The instream flow appropriations are measured at the North Bend gage and the Louisville gage, although the appropriations extend to the confluence with the Missouri River. When instream flow appropriations are not met at the North Bend gage, all junior surface water appropriations above that gage, including those in the Loup River Basin, are closed to diversion (Figure 7-2). When instream flow appropriations are not met at both the North Bend and the Louisville gages, all junior surface water appropriations above both gages, including those in both the Loup and Elkhorn River subbasins, are closed to diversion. In circumstances where the instream flow appropriation is being met at the North Bend gage but not at the Louisville gage, all junior appropriations above the Louisville gage, including those in both the Loup and Elkhorn River subbasins, are closed to diversion.

Administration for the instream flow rights did not begin until 1997, when the permits were actually issued. Therefore, to evaluate a 20-year record, the Department had to determine the number of days in which administration would have occurred if the instream flow rights had been in existence for the entire period of evaluation (1996-2015). Between 1996 and 2015, the junior surface water appropriations above North Bend, including those in the Loup River subbasin, would have been closed due to the instream flow appropriations not being met during July and August (the 65 percent time period from the 65/85 rule) for a total of 396 days. The junior surface water appropriations downstream of North Bend but upstream of Louisville would have been closed due to the instream flow appropriation not being met during July and August for a total of 378 days.

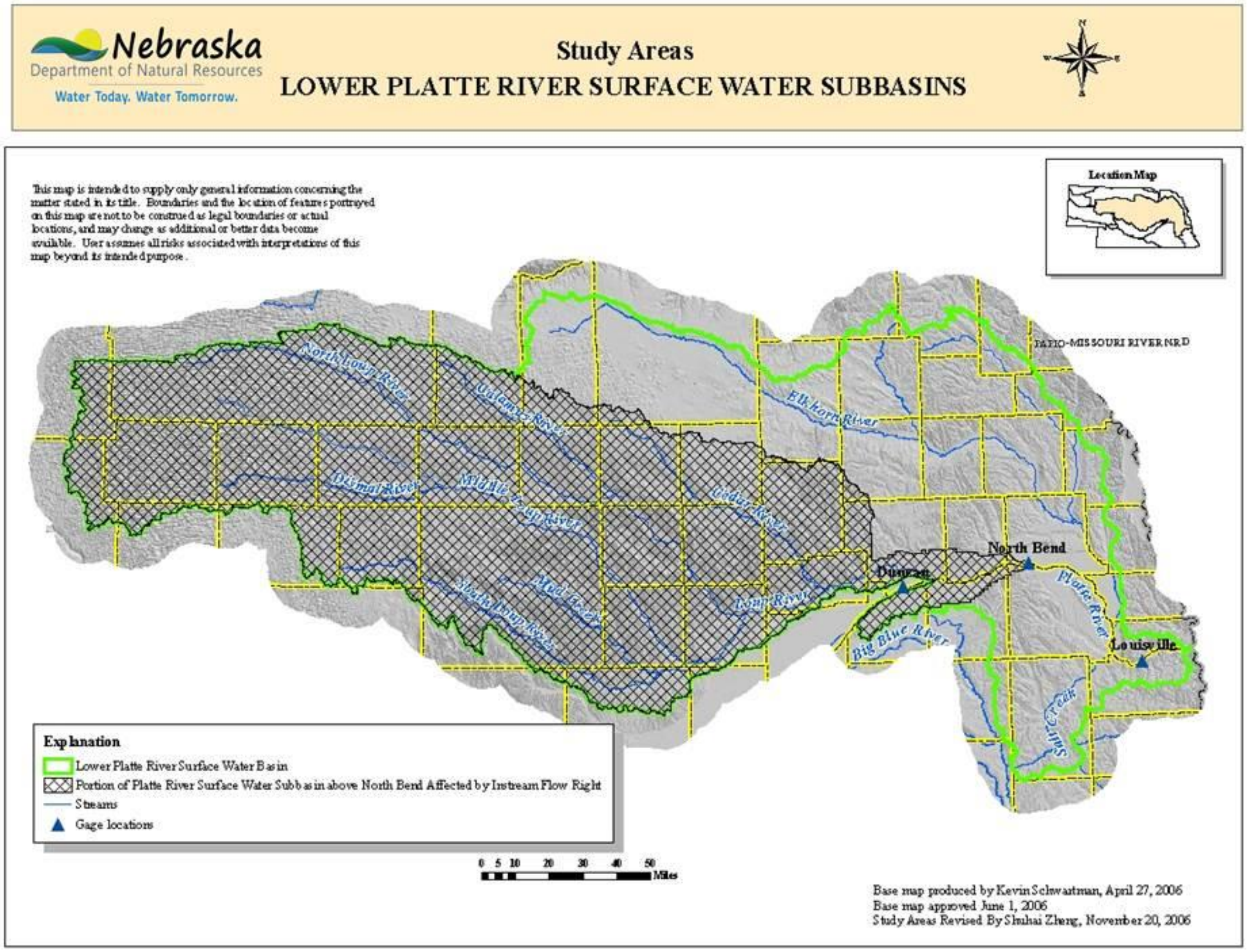

Figure 7-2. Map of the Platte River Basin highlighting the subbasin above the North Bend gage.

7.4 Nature and Extent of Water Use

7.4.1 Groundwater

Groundwater in the Lower Platte River Basin is used for a variety of purposes: domestic, industrial, livestock, irrigation, and other uses. A total of 49,092 groundwater wells had been registered within the basin as of December 31, 2015 (Department registered groundwater wells database) (Figure 7-3). The locations of all active groundwater wells can be seen in Figure 7-4.

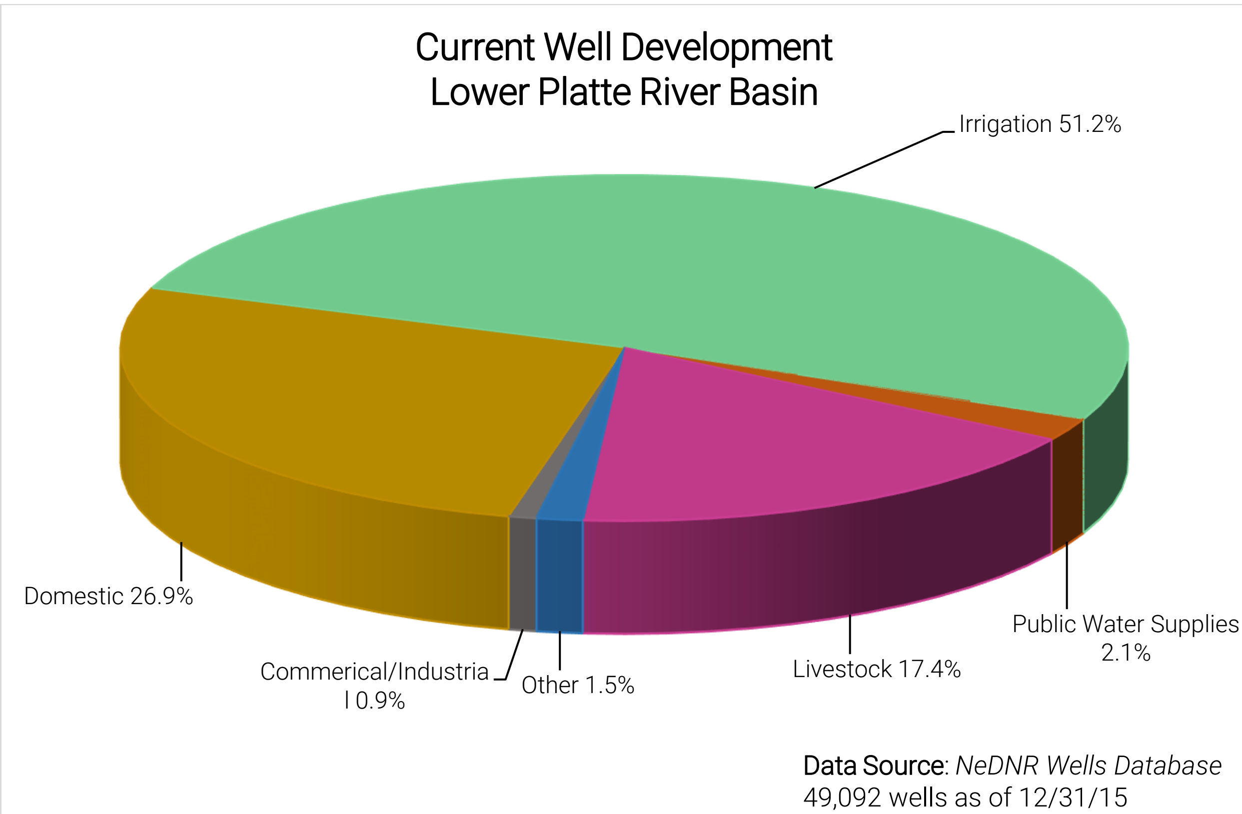

Figure 7-3. Current well development by number of registered wells, Lower Platte River Basin.

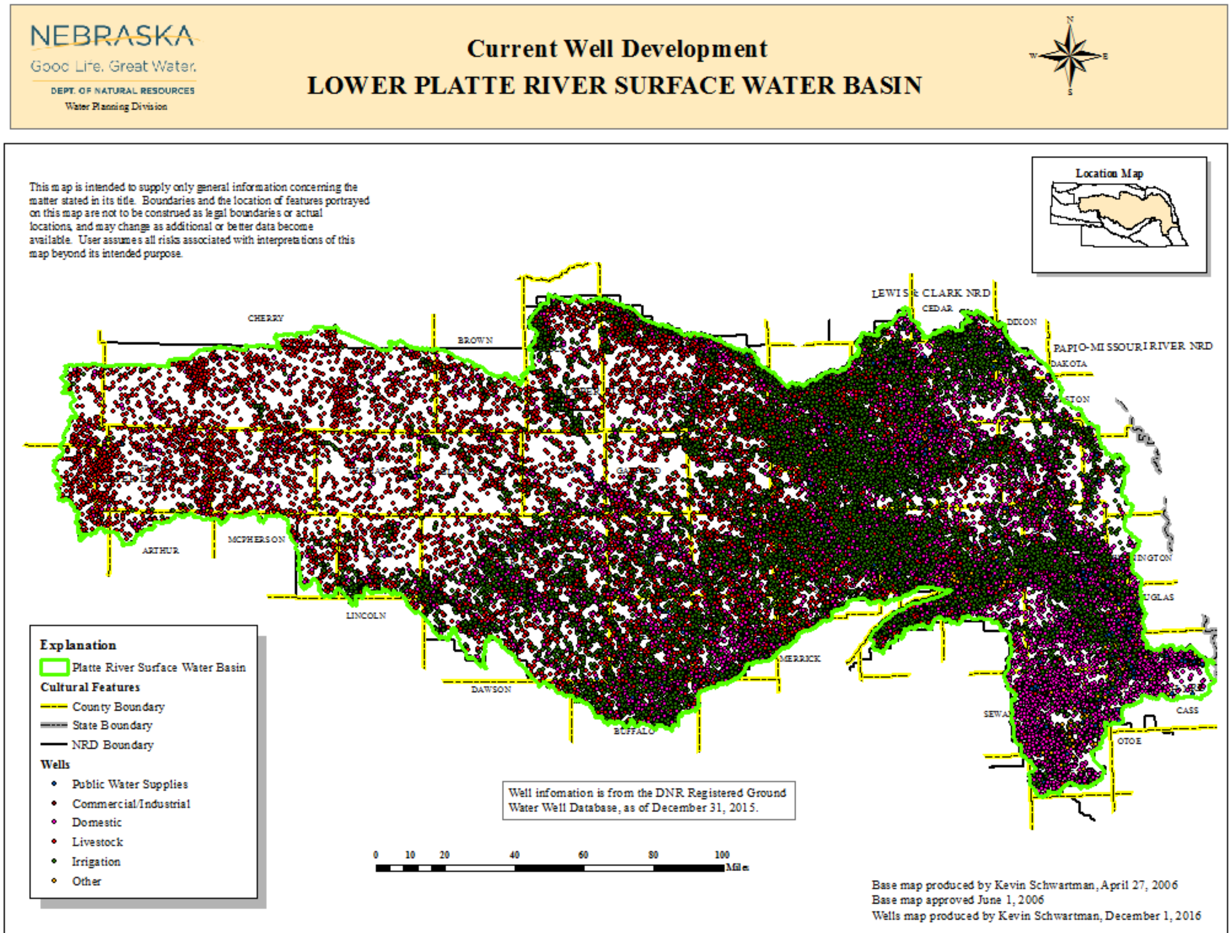

Figure 7-4. Current well locations, Lower Platte River Basin.

7.4.2 Surface Water

As of December 31, 2015, 2,250 surface water appropriations were held in the Lower Platte River Basin, issued for a variety of uses (Figure 7-5). Most of the surface water appropriations are for irrigation use and tend to be located on the major streams. In addition, two instream flow appropriations are held in the basin. The instream flow appropriations are located on the Platte River and are measured at North Bend and Louisville. The first surface water appropriations in the basin were permitted in 1890 and development has continued through the present day. The approximate locations of the surface water diversion points are shown in Figure 7-6.

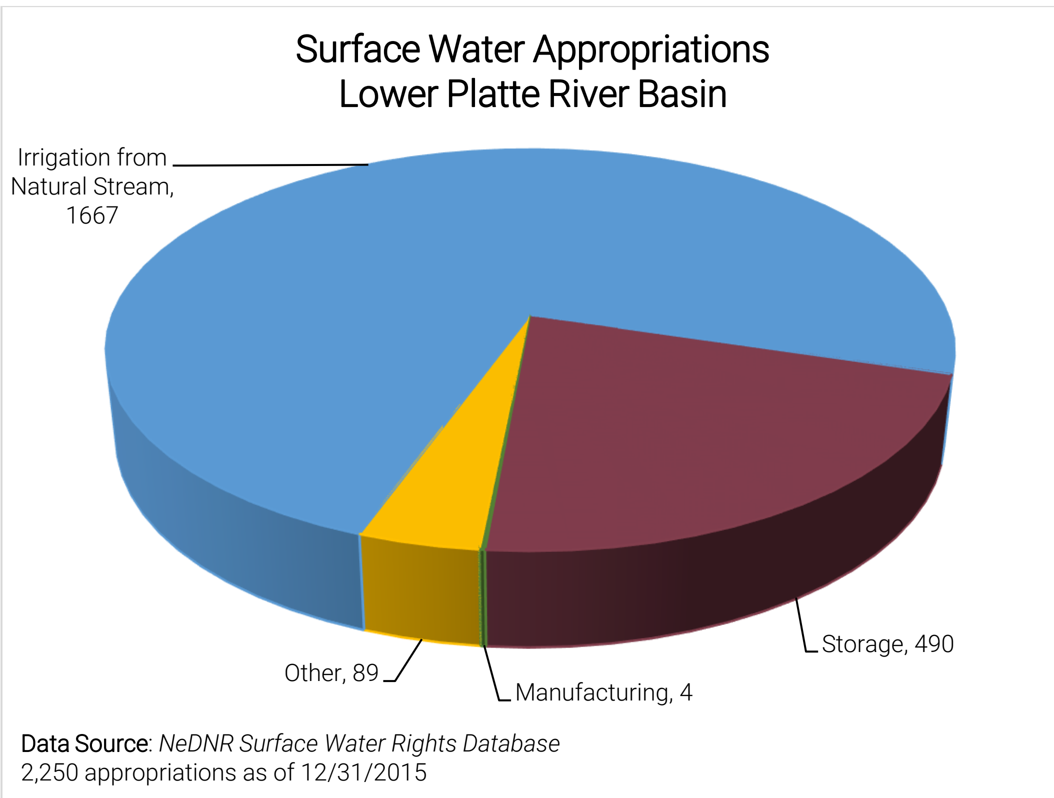

Figure 7-5. Surface water appropriations by number of diversion points, Lower Platte River Basin.

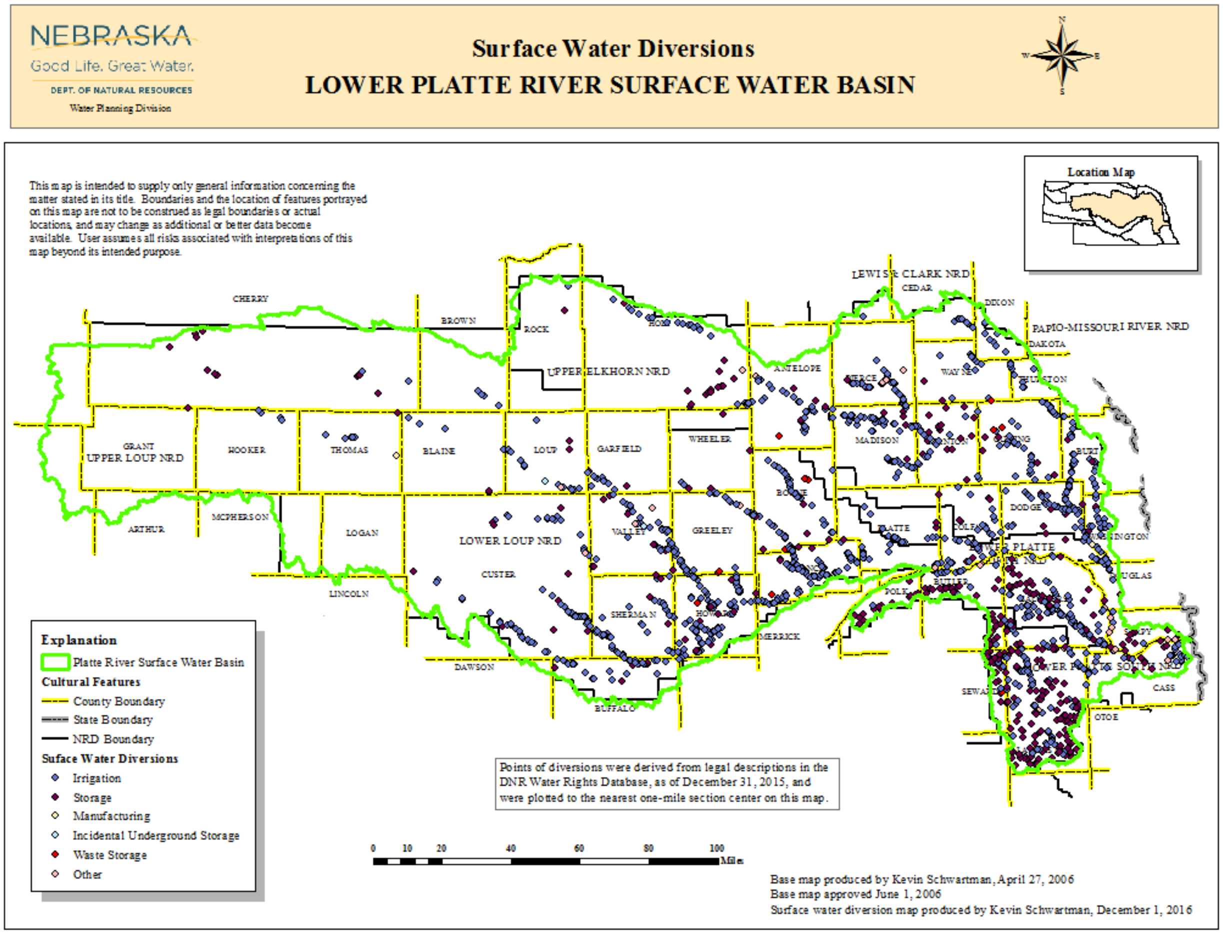

Figure 7-6. Surface water appropriation diversion locations, Lower Platte River Basin.

7.5 Hydrologically Connected Area

The Central Nebraska Model (CENEB) was used to determine the extent of the 10/50 area for the Loup River Basin and portions of the Elkhorn River Basin. In areas that were not covered by the CENEB but were considered to be hydrologically connected, the 10/50 area was determined using stream depletion factor (SDF) methodology. Figure 7-7 specifies the extent of the 10/50 area. A description of the SDF methodology used appears in Appendix C of this report.

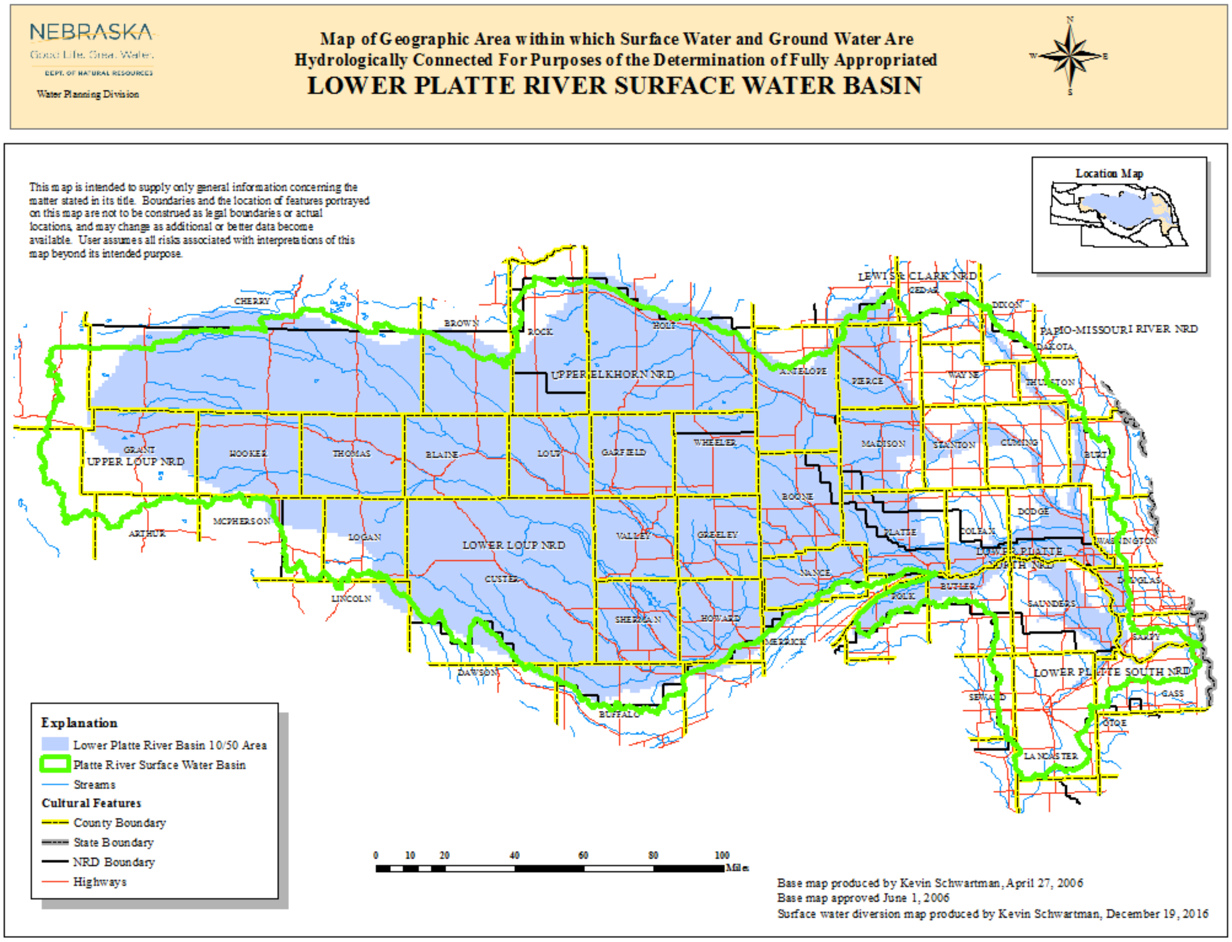

Figure 7-7. 10/50 area, Lower Platte River Basin.

7.6 Net Corn Crop Irrigation Requirement

Figure 7-8 is a map of the net corn crop irrigation requirement (NCCIR) for the Lower Platte River Basin (DNR, 2005). The NCCIR for a junior surface water appropriation above the North Bend gage is 10.52 inches. To assess the number of days required to be available for diversion, a surface water diversion rate equal to 1 cfs per 70 acres, a downtime of 10 percent, and an irrigation efficiency of 80 percent were assumed. Based on these assumptions, the most junior surface water appropriations would need 27.9 days annually to divert 65 percent of the NCCIR and 36.5 days to divert 85 percent of the NCCIR.

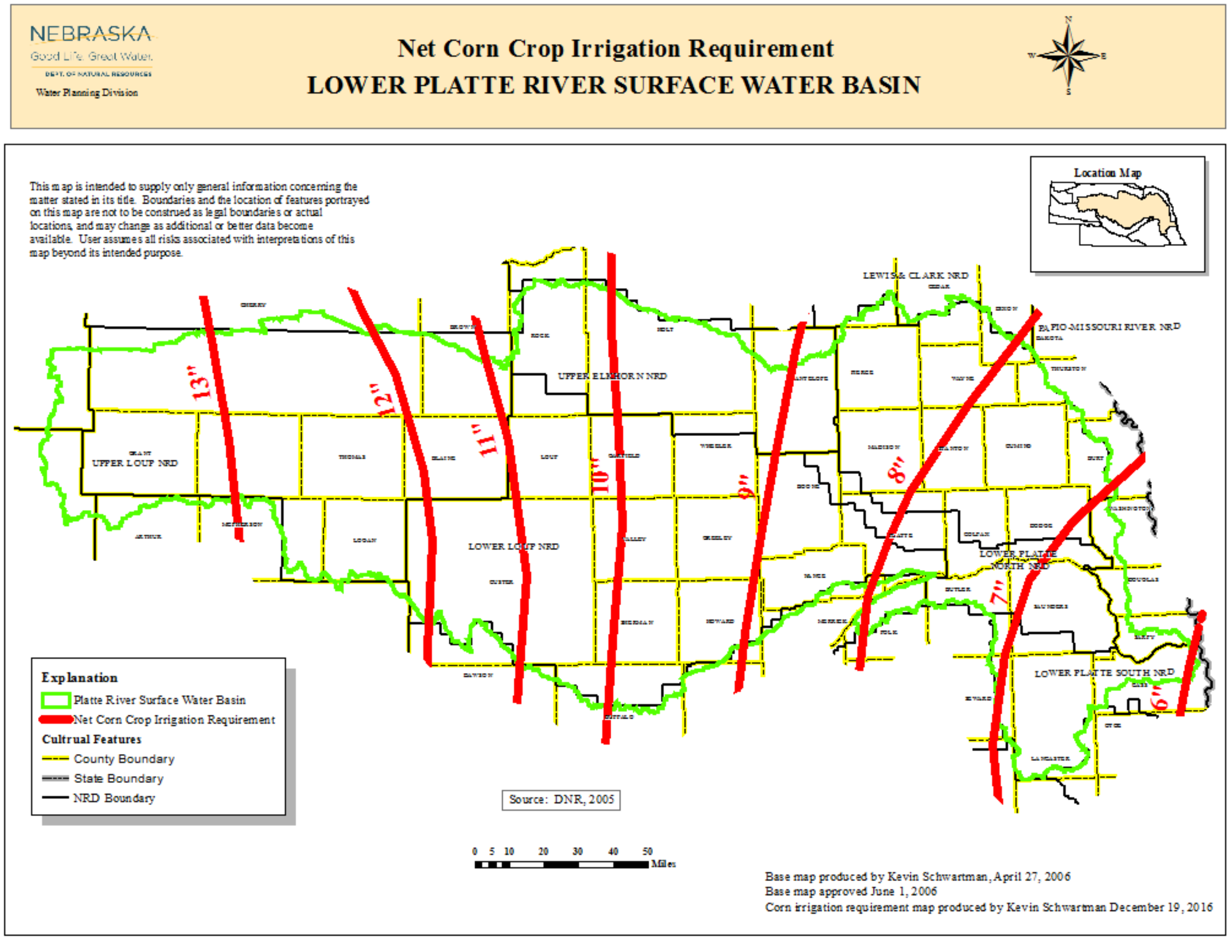

Figure 7-8. Net corn crop irrigation requirement (NCCIR), Lower Platte River Basin.

7.7 Surface Water Closing Records

Tables 7-1 and 7-2 record all surface water administration that has occurred in the basin upstream of the North Bend and Louisville gages, respectively, between 1996 and 2015.

Table 7-1. Surface water administration in the Lower Platte River Basin upstream of the North Bend gage, 1996-2015.[3]

Year	Water Body	Days	Closing Date	Opening Date
2000	Lower Platte River Basin above North Bend	53	Aug 8	Sep 30
2001	Lower Platte River Basin above North Bend	11	Aug 7	Aug 18
2002	Lower Platte River Basin above North Bend	6	Jun 6	Jun 12
2002	Lower Platte River Basin above North Bend	67	Jun 25	Aug 31
2002	Lower Platte River Basin above North Bend	24	Sep 6	Sep 30
2003	Lower Platte River Basin above North Bend	81	Jul 11	Sep 30
2004	Lower Platte River Basin above North Bend	13	May 6	May 19
2004	Lower Platte River Basin above North Bend	7	Jun 29	Jul 6
2004	Lower Platte River Basin above North Bend	58	Jul 27	Sep 23
2005	Lower Platte River Basin above North Bend	48	Jul 12	Aug 29
2005	Lower Platte River Basin above North Bend	28	Sep 2	Sep 30
2006	Lower Platte River Basin above North Bend	35	May 15	Jun 20
2006	Lower Platte River Basin above North Bend	45	Jun 26	Aug 10
2006	Lower Platte River Basin above North Bend	28	Aug 14	Sep 11
2006	Lower Platte River Basin above North Bend	22	Oct 5	Oct 27
2006	Lower Platte River Basin above North Bend	20	Oct 31	Nov 20
2007	Lower Platte River Basin above North Bend	5	Jul 9	July 14
2008	Lower Platte River Basin above North Bend	3	Aug 8	Aug 11
2008	Lower Platte River Basin above North Bend	4	Aug 25	Aug 29
2008	Lower Platte River Basin above North Bend	6	Sep 2	Sep 8
2012	Lower Platte River Basin above North Bend	103	Jun 15	Sep 30
2013	Lower Platte River Basin above North Bend	29	Jul 8	Aug 6
2013	Lower Platte River Basin above North Bend	32	Aug 29	Sep 30
2014	Lower Platte River Basin above North Bend	13	Jul 31	Aug 12

[3] Surface water administration for instream flows did not occur until 1997.

Table 7-2. Surface water administration in the Lower Platte River Basin downstream of the North Bend gage and upstream of the Louisville gage 1996-2015.

Year	Water Body	Days	Closing Date	Opening Date
2000	Lower Platte River Basin above Louisville	53	Aug 8	Sep 30
2001	Lower Platte River Basin above Louisville	11	Aug 7	Aug 18
2002	Lower Platte River Basin above Louisville	6	Jun 6	Jun 12
2002	Lower Platte River Basin above Louisville	59	Jun 25	Aug 23
2002	Lower Platte River Basin above Louisville	4	Aug 27	Aug 31
2002	Lower Platte River Basin above Louisville	24	Sep 6	Sep 30
2003	Lower Platte River Basin above Louisville	66	Jul 14	Sep 18
2004	Lower Platte River Basin above Louisville	13	May 6	May 19
2004	Lower Platte River Basin above Louisville	7	Jun 29	Jul 6
2004	Lower Platte River Basin above Louisville	58	Jul 27	Sep 23
2005	Lower Platte River Basin above Louisville	14	Jul 12	Jul 26
2005	Lower Platte River Basin above Louisville	31	Jul 29	Aug 29
2005	Lower Platte River Basin above Louisville	28	Sep 2	Sep 30
2006	Lower Platte River Basin above Louisville	35	May 16	Jun 20
2006	Lower Platte River Basin above Louisville	45	Jun 26	Aug 10
2006	Lower Platte River Basin above Louisville	28	Aug 14	Sep 11
2006	Lower Platte River Basin above Louisville	22	Oct 5	Oct 27
2006	Lower Platte River Basin above Louisville	20	Oct 31	Nov 20
2007	Lower Platte River Basin above Louisville	5	July 9	July 14
2008	Lower Platte River Basin above Louisville	4	Aug 25	Aug 29
2008	Lower Platte River Basin above Louisville	6	Sep 2	Sep 8
2012	Lower Platte River Basin above Louisville	103	Jun 19	Sep 30
2013	Lower Platte River Basin above Louisville	29	Jul 8	Aug 6
2013	Lower Platte River Basin above Louisville	32	Aug 29	Sep 30
2014	Lower Platte River Basin above Louisville	13	Jul 31	Aug 12

7.8 Evaluation of Current Development

7.8.1 Current Water Supply

The current water supply is estimated by using the most recent 20-year period (1996-2015) of flows and comparing them to the flows necessary to satisfy the senior surface water appropriation (i.e., the instream flow appropriations). The results of the analyses conducted for the Lower Platte River Basin upstream of North Bend and downstream of North Bend and upstream of Louisville, respectively, are shown in Tables 7-3 and 7-4. The results indicate that the current surface water supply in the Lower Platte River Basin upstream of North Bend provides an average of 42.2 days available for diversion between July 1 and August 31 and 119.4 days available for diversion between May 1 and September 30 (Table 7-5). The results for the Lower Platte River Basin downstream of North Bend and upstream of Louisville indicate an average of 43.1 days available for diversion between July 1 and August 31 and 120.8 days available for diversion between May 1 and September 30 (Table 7-6).

Table 7-3. Estimate of the current number of days surface water is available for diversion upstream of North Bend.

Year	July 1 through August 31 Number of Days Surface Water is Available for Diversion	May 1 through September 30 Number of Days Surface Water is Available for Diversion
1996	62	153
1997	62	153
1998	62	153
1999	62	153
2000	39	100
2001	51	142
2002	0	56
2003	11	72
2004	22	75
2005	14	77
2006	5	45
2007	57	148
2008	55	140
2009	62	153
2010	62	153
2011	62	153
2012	15	76
2013	30	92
2014	49	140
2015	62	153
Average	42.2	119.4

Table 7-4. Estimate of the current number of days surface water is available for diversion downstream of North Bend and upstream of Louisville.

Year	July 1 through August 31 Number of Days Surface Water is Available for Diversion	May 1 through September 30 Number of Days Surface Water is Available for Diversion
1996	62	153
1997	62	153
1998	62	153
1999	62	153
2000	39	100
2001	51	142
2002	4	60
2003	14	87
2004	22	75
2005	17	80
2006	5	45
2007	57	148
2008	58	143
2009	62	153
2010	62	153
2011	62	153
2012	19	80
2013	30	92
2014	49	140
2015	62	153
Average	43.1	120.8

Table 7-5. Comparison between the number of days required to meet the net corn crop irrigation requirement and number of days surface water is available for diversion upstream of North Bend.

	Number of Days Necessary to Meet the 65% and 85% of Net Corn Crop Irrigation Requirement	Average Number of Days Available for Diversion with Current Development
July 1 – August 31 (65% Requirement)	27.9	42.2 (14.3 days above the requirement)
May 1 – September 30 (85% Requirement)	36.5	119.4 (82.9 days above the requirement)

Table 7-6. Comparison between the number of days required to meet the net corn crop irrigation requirement and number of days surface water is available for diversion downstream of North Bend and upstream of Louisville.

	Number of Days Necessary to Meet the 65% and 85% of Net Corn Crop Irrigation Requirement	Average Number of Days Available for Diversion with Current Development
July 1 – August 31 (65% Requirement)	27.9	43.1 (15.2 days above the requirement)
May 1 – September 30 (85% Requirement)	36.5	120.8 (84.3 days above the requirement)

7.8.2 Water Supply

In order to complete the long-term evaluation of surface water supplies, a future 20-year water supply for the Lower Platte River Basin must be estimated. The basin's major water sources are precipitation, which runs off as direct streamflow and infiltrates into the ground to discharge as baseflow; groundwater movement into the basin, which discharges as baseflow; and streamflow from the middle Platte River. Using methodology published in the *Journal of Hydrology* (Wen and Chen, 2005), a nonparametric Mann-Kendall trend test of the weighted average precipitation in the basin was completed. The analysis showed no statistically significant trend in precipitation ($P > 0.95$) over the past 50 years (Figure 7-9). The same type of statistical analysis of streamflow from the middle Platte River (using the Platte River at Duncan gage as inflow to the Lower Platte Basin), also showed no statistically significant trend ($P > 0.95$) for reduction of inflows (Figure 7-10). Therefore, using the previous 20 years of precipitation and streamflow data as the best estimate of the future surface water supply is a reasonable starting point for applying the lag depletions from groundwater wells.

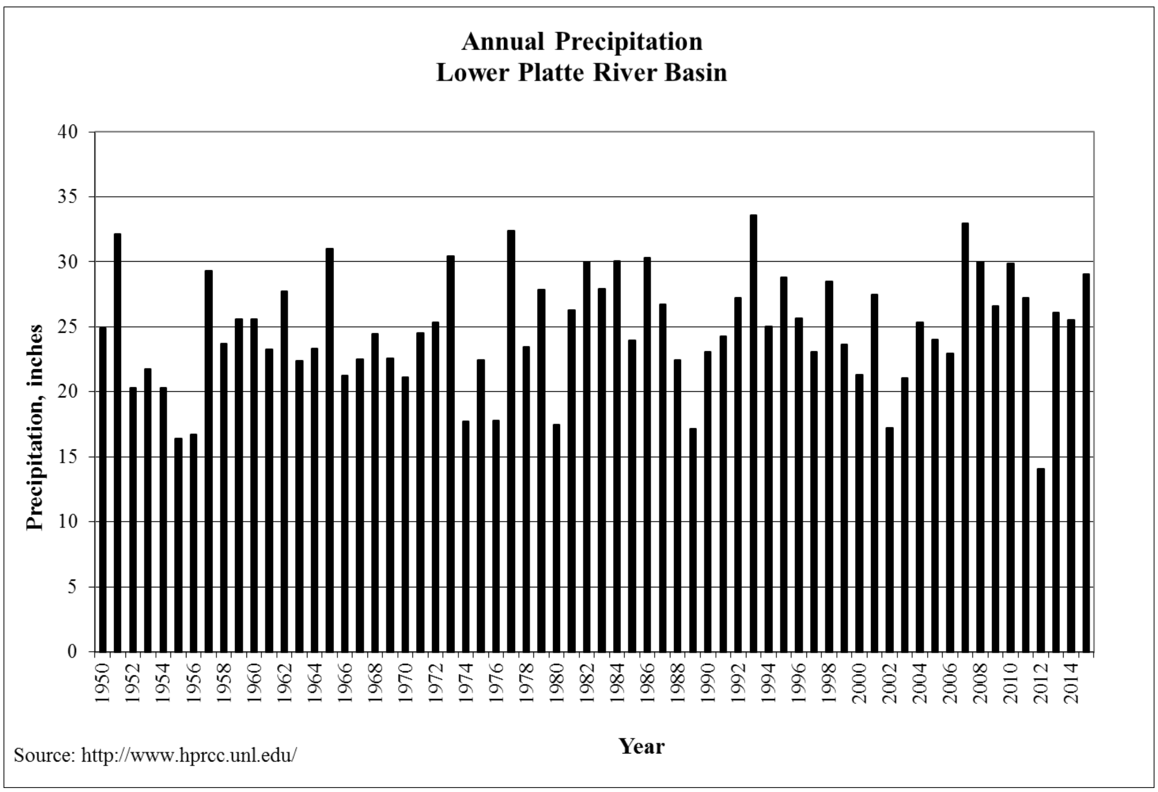

Figure 7-9. Annual precipitation, Lower Platte River Basin.[4]

[4] The results include precipitation stations covering the Loup, Elkhorn, and Platte River Basins.

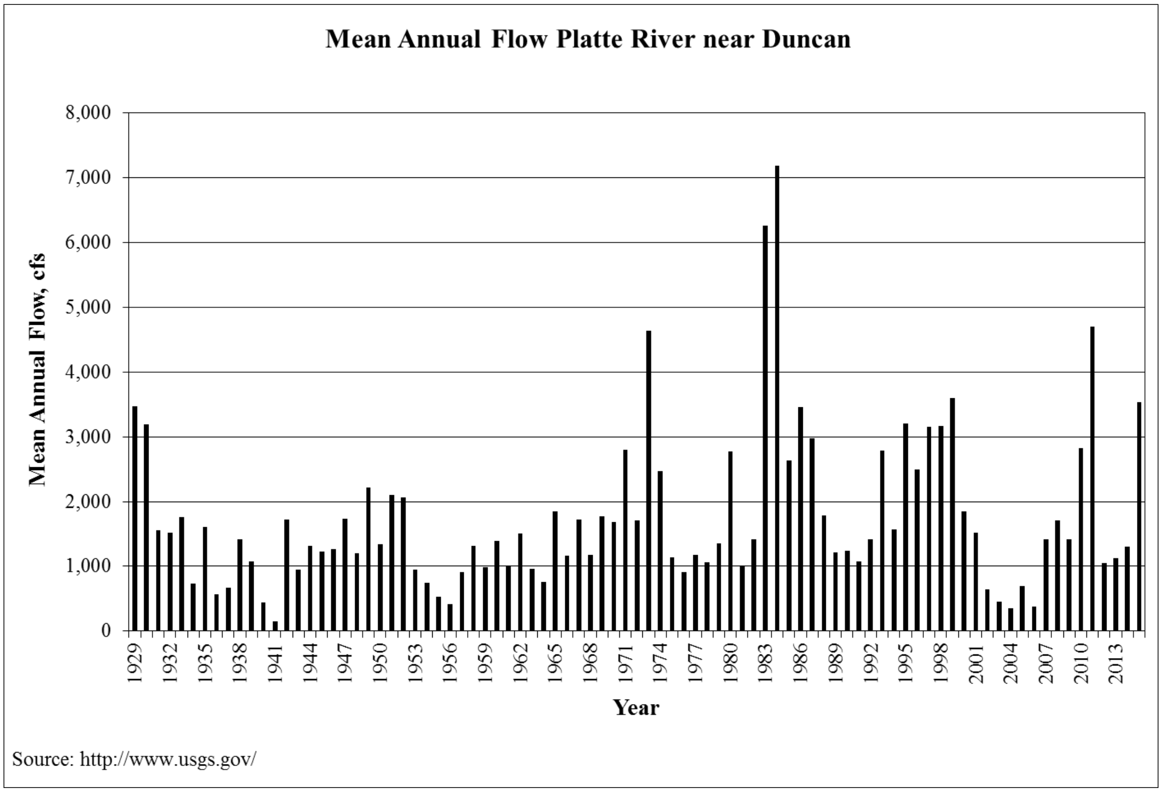

Figure 7-10. Mean annual flow, Platte River near Duncan.

7.8.3 Depletions Analysis

The future depletions due to current well development that could be expected to affect streamflow in the Lower Platte River Basin were estimated using the CENEB Model for the Loup River Basin and portions of the Elkhorn River Basin, whereas the SDF methodology was used in all other areas where data exist. The results estimate the future streamflow at North Bend to be depleted by 35 cfs in 25 years. The results estimate the future streamflow at Louisville to be depleted by 337 cfs in 25 years. The 337 cfs depletion at Louisville includes the 35 cfs at North Bend; 6 cfs calculated using the results of the CENEB Model for the Elkhorn River upstream of Norfolk; 15 cfs calculated using the Jenkins method for areas downstream of North Bend and downstream of Norfolk but upstream of the Louisville gage; 160 cfs[5] from the Metropolitan Utilities District's Platte West wellfield,

[5] This is the maximum amount of water that is permitted to be pumped from the stream by the wellfield, not the entire amount of streamflow for which the induced recharge permit was granted.

located on the Platte River upstream of the confluence of the Platte and Elkhorn Rivers; and 121 cfs[6] from Lincoln Water System's wellfield, located on the Platte River near Ashland.

7.8.4 Evaluation of Current Levels of Development against Future Water Supplies

The estimates of the 20-year average number of days available for diversion are calculated by comparing the lag-adjusted future water supply with the flows necessary to satisfy the senior calling surface water appropriations (in this case, the instream flow rights) that have caused administration of junior appropriations in the Lower Platte River Basin. The results of the analyses are shown in Tables 7-7 and 7-8. The results of the analyses as compared to the numbers of days surface water is required to be available to divert 65 percent and 85 percent of the NCCIR are detailed in Tables 7-9 and 7-10. The long-term surface water supply estimates, given current levels of development, are sufficient to meet the needs of the most junior surface water appropriations for the Lower Platte River Basin upstream of North Bend.

[6] This is the difference between the maximum amount of water permitted to be pumped from the stream by the wellfield and the best estimate of average July-August water currently being pumped from the stream by the wellfield.

Table 7-7. Estimate of days surface water is available for diversion upstream of North Bend with current development and 25-year lag impacts.

Year	July 1 through August 31 Number of Days Surface Water is Available for Diversion	May 1 through September 30 Number of Days Surface Water is Available for Diversion
1	62	153
2	62	153
3	61	150
4	62	153
5	34	94
6	45	129
7	0	51
8	10	71
9	18	67
10	10	73
11	5	44
12	52	143
13	52	137
14	62	153
15	62	153
16	62	153
17	15	75
18	22	83
19	48	139
20	62	149
Average	40.3	116.2

Table 7-8. Estimate of days surface water is available for diversion downstream of North Bend and upstream of Louisville with current development and 25-year lag impacts.

Year	July 1 through August 31 Number of Days Surface Water is Available for Diversion	May 1 through September 30 Number of Days Surface Water is Available for Diversion
1	62	153
2	61	152
3	62	151
4	62	153
5	35	95
6	44	128
7	3	55
8	12	85
9	17	65
10	12	75
11	4	42
12	52	143
13	52	134
14	62	153
15	62	153
16	62	153
17	19	76
18	22	83
19	47	138
20	62	153
Average	40.7	117.0

Table 7-9. Comparison between the number of days required to meet the net corn crop irrigation requirement and number of days surface water is available for diversion upstream of North Bend with current development and lag impacts.

	Number of Days Necessary to Meet the 65% and 85% of Net Corn Crop Irrigation Requirement	Average Number of Days Available for Diversion at Current Development with 25 Years of Lag Impacts
July 1 – August 31 (65% Requirement)	27.9	40.3 (12.4 days above the requirement)
May 1 – September 30 (85% Requirement)	36.5	116.2 (79.7 days above the requirement)

Table 7-10. Comparison between the number of days required to meet the net corn crop irrigation requirement and number of days surface water is available for diversion downstream of North Bend and upstream of Louisville with current development and lag impacts.

	Number of Days Necessary to Meet the 65% and 85% of Net Corn Crop Irrigation Requirement	Average Number of Days Available for Diversion at Current Development with 25 Years of Lag Impacts
July 1 – August 31 (65% Requirement)	27.9	40.7 (12.8 days above the requirement)
May 1 – September 30 (85% Requirement)	36.5	117.0 (80.5 days above the requirement)

7.9 Evaluation of Predicted Future Development

Estimates of the number of high capacity wells (wells pumping greater than 50 gpm) that would be completed over the next 25 years, if no new legal constraints on the construction of such wells were imposed, were calculated based on extrapolating the present-day rate of increase in well development into the future (Figure 7-11). The present-day rate of development is based on the linear trend of the previous 10 years of development. Based on the analysis of the past 10 years of development, the rate of increase in high capacity wells is estimated to be 237 wells per year in the Lower Platte River Basin.

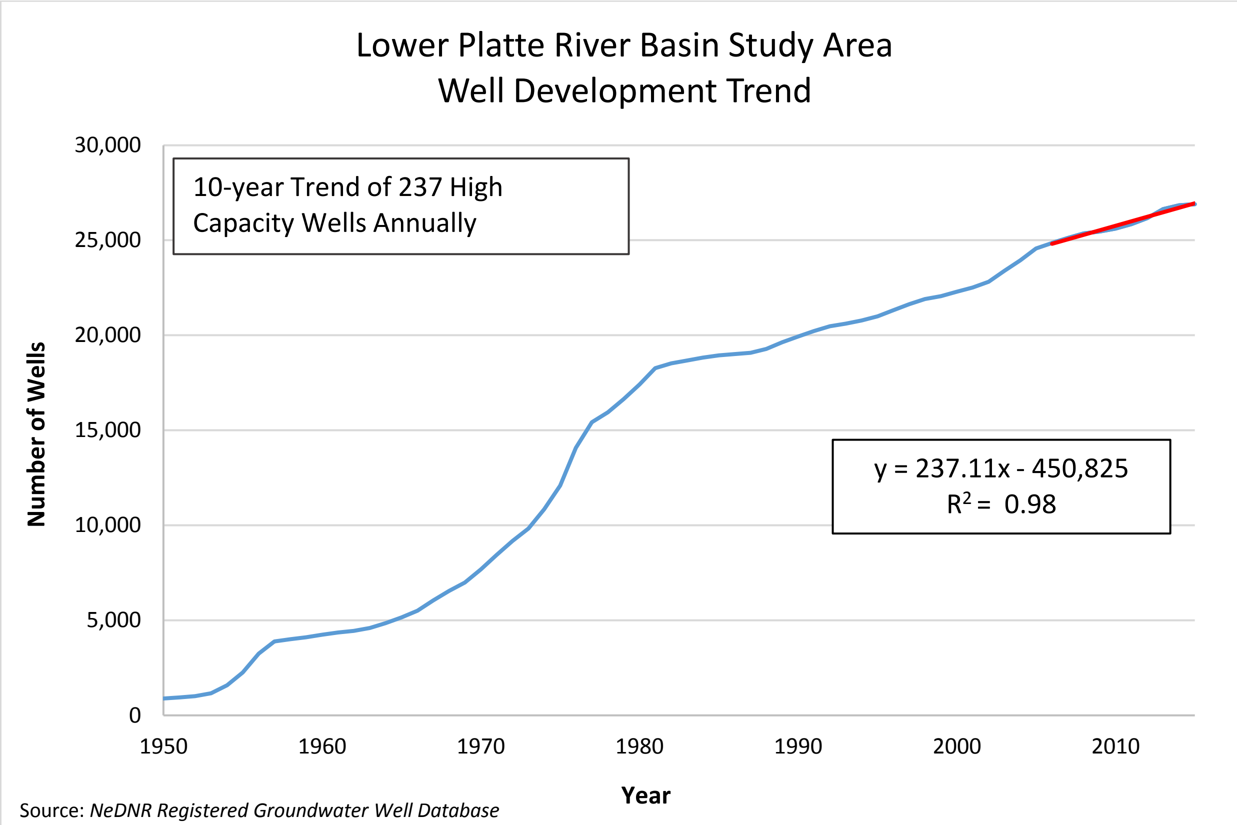

Figure 7-11. High capacity well development, Lower Platte River Basin.

The future depletions due to current and future well development that could be expected to affect streamflow in the basin were estimated using the CENEB Model and the SDF methodology. The results estimate the future streamflow at North Bend to be depleted by an additional 71 cfs in 25 years. The results estimate the future streamflow at Louisville to be depleted by an additional 122 cfs in 25 years. The Louisville estimate includes the 71 cfs of depletion due to projected future irrigation development upstream of North Bend and 51 cfs of depletion due to projected future irrigation development downstream of North Bend.

The estimate of the 20-year average number of days surface water is available for diversion with additional future development is calculated by comparing the future lag-adjusted flow with the flows necessary to satisfy the senior surface water appropriation. The results of the analyses are shown in Tables 7-11 and 7-12. The results of the analyses as compared to the numbers of days surface water is required to be available to divert 65 percent and 85 percent of the NCCIR are detailed in Tables 7-13 and 7-14. The results indicate that, based on current information, the Department's conclusion that the basin is not fully appropriated would not change if no additional constraints are placed on future development of surface water and groundwater in the basin.

Table 7-11. Estimated number of days surface water is available for diversion upstream of North Bend with current and predicted future development.

Year	July 1 through August 31 Number of Days Surface Water is Available for Diversion	May 1 through September 30 Number of Days Surface Water is Available for Diversion
1	61	152
2	60	151
3	61	149
4	62	153
5	30	90
6	42	124
7	0	50
8	10	71
9	18	63
10	10	73
11	5	41
12	49	140
13	49	131
14	60	151
15	62	153
16	62	153
17	15	74
18	18	78
19	48	139
20	60	144
Average	39.1	114.0

Table 7-12. Estimated number of days surface water is available for diversion downstream of North Bend and upstream of Louisville with current and predicted future development.

Year	July 1 through August 31 Number of Days Surface Water is Available for Diversion	May 1 through September 30 Number of Days Surface Water is Available for Diversion
1	61	152
2	61	152
3	62	150
4	62	153
5	32	92
6	43	125
7	3	54
8	11	84
9	17	61
10	12	75
11	4	39
12	49	140
13	48	130
14	61	152
15	62	153
16	62	153
17	19	75
18	18	78
19	47	138
20	62	153
Average	39.8	115.5

Table 7-13. Comparison between the number of days required to meet the net corn crop irrigation requirement and number of days surface water is available for diversion upstream of North Bend with current and predicted future development.

	Number of Days Necessary to Meet the 65% and 85% of Net Corn Crop Irrigation Requirement	Average Number of Days Available for Diversion with Future Development and 25 Years of Lag Impacts
July 1 – August 31 (65% Requirement)	27.9	39.1 (11.2 days above the requirement)
May 1 – September 30 (85% Requirement)	36.5	114.0 (77.5 days above the requirement)

Table 7-14. Comparison between the number of days required to meet the net corn crop irrigation requirement and number of days surface water is available for diversion downstream of North Bend and upstream of Louisville with current and predicted future development.

	Number of Days Necessary to Meet the 65% and 85% of Net Corn Crop Irrigation Requirement	Average Number of Days Available for Diversion with Future Development and 25 Years of Lag Impacts
July 1 – August 31 (65% Requirement)	27.9	39.8 (11.9 days above the requirement)
May 1 – September 30 (85% Requirement)	36.5	115.5 (79.0 days above the requirement)

7.10 Instream Flow Surface Water Appropriation Analysis

During the non-irrigation season, the junior water rights in the Lower Platte River system are the Nebraska Game and Parks Commission’s instream flow rights. The purpose of these rights is to maintain habitat for the fish community. Therefore, the Department determined that an appropriate standard of interference would be to determine whether the instream flow requirements that could be met at the time the water rights were granted can still be met today.

To calculate the average monthly flow that the instream flow permits could have expected at the time they were granted, the 20-year period prior to the permits being granted (1974-1993) was used. In conducting this analysis, the lag impacts were calculated for development through 1993 and subtracted from the daily flows (see Section 4.2.4 for more detail). The average number of days that flows were available for each month at the time the appropriations were obtained was compared with the current average number of days that flows are available for each month. The results are shown in Table 7-15 and 7-16.

Results indicate that neither the North Bend instream flow appropriation nor the Louisville instream flow appropriations are projected to experience significant erosion with inclusion of the 25 year lag-effects. Thus, the long-term surface water supply estimate in the basin is sufficient for the instream flow appropriations in the basin, based on the current level of development and the calculated 25 year lag impacts

Table 7-15. Number of days North Bend instream flow appropriation expected to be met.

Month	Number of Days Flows Met at Time of Application *	Number of Days Flows Met With Current Development °	Difference in the Number of Days Instream Flow Appropriation is Currently Met
October	16.7	20.9	4.3
November	21.8	21.8	0.0
December	20.2	22.4	2.2
January	22.5	23.6	1.2
February	24.1	23.9	0.3
March	30.8	29.9	-0.9
April	28.5	29.3	0.9
May	27.5	28.3	0.8
June	23.3	24.9	1.6
July	13.9	17.4	3.5
August	12.7	15.6	2.9
September	14.9	17.6	2.7

Month	Number of Days Flows Met at Time of Application *	Number of Days Flows Met With Current Development °	Difference in the Number of Days Instream Flow Appropriation is Currently Met
October	16.7	21.0	4.3
November	21.9	21.9	0.0
December	20.5	22.8	2.3
January	22.8	24.3	1.5
February	24.2	24.0	-0.2
March	30.8	30.1	-0.8
April	28.5	29.3	0.8
May	27.6	28.9	1.3
June	23.5	26.2	2.7
July	14.7	18.9	4.3
August	13.4	16.5	3.1
September	15.1	18.4	3.3

Table 7-16. Number of days Louisville instream flow appropriation expected to be met.

7.11 Sufficiency to Avoid Noncompliance

There are no interstate compacts or decrees, or other formal state contracts or agreements in the Lower Platte River Basin that could be affected by reduced streamflows. There are state and federally endangered and threatened species in the Lower Platte River Basin. The requirements of the Nebraska Nongame and Endangered Species Conservation Act (NNESCA) and the federal Endangered Species Act (ESA) prevent actions that could cause harmful stream flow reductions. At this time, there is sufficient water supply in the basin to comply with NNESCA and the ESA. Because future development will be limited so as to continue compliance with NNESCA, the long-term surface water supply in the basin is sufficient.

* The number of days instream flows would be expected to be met at the time of application (1974-1993) with lag effects of well development at the time of the appropriation.

° The number of days instream flows would be expected to be met at current time (1996-2015) with lag effects of current well development.

7.12 Current Studies Being Conducted to Assist with Future Analysis

Studies of note that are currently being conducted within the Lower Platte River Basin are the Eastern Nebraska Water Resources Assessment (ENWRA) and the Elkhorn-Loup groundwater model (ELM) Phase III study. ENWRA is an effort between several agencies to categorize the aquifer characteristics and the water supply of the glaciated portion of eastern Nebraska, which includes large areas of the Lower Platte River Basin. This work may provide data for use in future reports. The ELM study is working to further refine the ELM Phase II groundwater model which covers a substantial portion of the Lower Platte River Basin and which was utilized, in part, as a starting point for development of the Department's CENEB Model. The Department will evaluate future results from this study and may utilize information from this study in future reports. The Department has completed the development of a numerical groundwater model for eastern portions of the basin. The modeling and documentation for this work has been completed and is currently undergoing peer review.

Additionally, significant progress has been made on the voluntary integrated management plans in the Lower Platte River Basin. The Upper Loup, Lower Loup Lower Platte South, and Papio-Missouri River NRDs have completed voluntary plans with the Department and the Upper Elkhorn, Lower Elkhorn, and Lower Platte North NRDs are all in developmental phases.

The Department and the seven NRDs within the Lower Platte River Basin are working to develop a basin-wide plan to guide future development of individual integrated management plans.

7.13 Relevant Data Provided by Interested Parties

The Department published a request for relevant data from interested parties for this year’s evaluation on November 23, 2016 (see Appendix B for affidavit). The Department did not receive any such information.

7.14 Conclusions

Based on the analysis of the sufficiency of the long-term surface water supply in the Lower Platte River Basin, the Department has reached a conclusion that the Lower Platte River Basin upstream of the confluence with the Missouri River is presently not fully appropriated under the current rule. The Department has also determined that if no additional legal constraints are imposed on future development of hydrologically connected surface water and groundwater, and reasonable projections are made on the extent and location of future development, this conclusion would not change to a conclusion that the basin is fully appropriated, based on current information.

Although the basin has not been be determined to be fully appropriated using the methodology of the current rule, there may be times when supplies within a subbasin are not sufficient to meet all demands within that subbasin, as is shown by the Department's INSIGHT analysis. This is important for water managers to consider when developing a basin-wide plan or voluntary integrated management plan.

Bibliography of Hydrogeologic References for Lower Platte River Basin

Conservation and Survey Division. 2005. *Mapping of Aquifer Properties-Transmissivity and Specific Yield-for Selected River Basins in Central and Eastern Nebraska.* Lincoln.

Nebraska Department of Natural Resources. 2005. *2006 Annual Evaluation of Availability of Hydrologically Connected Water Supplies*. Lincoln.

Nebraska Department of Natural Resources. 2013. *Central Nebraska Groundwater Flow Model*. Lincoln.

Wen, F. J. and X. H. Chen, 2006. Evaluation of the Impact of Groundwater Irrigation on Streamflow Depletion in Nebraska. *Journal of Hydrology*, 327: 603-617.

8.0 MISSOURI TRIBUTARY BASINS

8.1 Summary

Based on the analysis of the sufficiency of the long-term surface water supply in the Missouri River Tributary Basins, the Department has reached a preliminary conclusion that the basins are not fully appropriated under the current rule. The use of the SDF methodology to determine lag effects of current development requires sufficient data and appropriate hydrogeologic conditions. Those data and conditions exist only in the Bazile Creek subbasin at this time. Therefore, lag effects of current development and potential future development were estimated only for the Bazile Creek subbasin.

The analysis of lag effects of current development for the Bazile Creek subbasin indicates a reduction in streamflows by 7 cfs in 25 years. The analysis of the impacts of future development on the Bazile Creek subbasin, based on current development trends, indicates an additional reduction in streamflows of 21 cfs in 25 years. The future number of days available to junior irrigators was not estimated because no surface water administration has occurred in the Bazile Creek subbasin in the past 20 years. Even though the future number of days available to junior irrigators was not estimated, the current number of days in which surface water was available for diversion far exceeds the number of days necessary to meet the net corn crop irrigation requirement (NCCIR).

8.2 Basin Descriptions

The Missouri Tributary Basins include all surface areas that drain directly into the Missouri River, with the exception of the Niobrara River and Platte River Basins, and all aquifers that impact surface water flows in the basins (Figure 8-1). Major streams in these basins include Ponca Creek, Bazile Creek, Weeping Water Creek, the Little Nemaha River, and the Big Nemaha River. The total area of the Missouri Tributary surface water basins is approximately 6,200 square miles, of which approximately 450 square miles drain into the Missouri River above the Niobrara River confluence; approximately 3,000 square miles drain into the Missouri River between the Niobrara River confluence and the Platte River confluence; and 2,800 square miles drain into the Missouri River below the Platte River confluence. NRDs with significant area in the basins are the Lower Niobrara, the Lewis and Clark, the Papio-Missouri River, and the Nemaha NRDs.

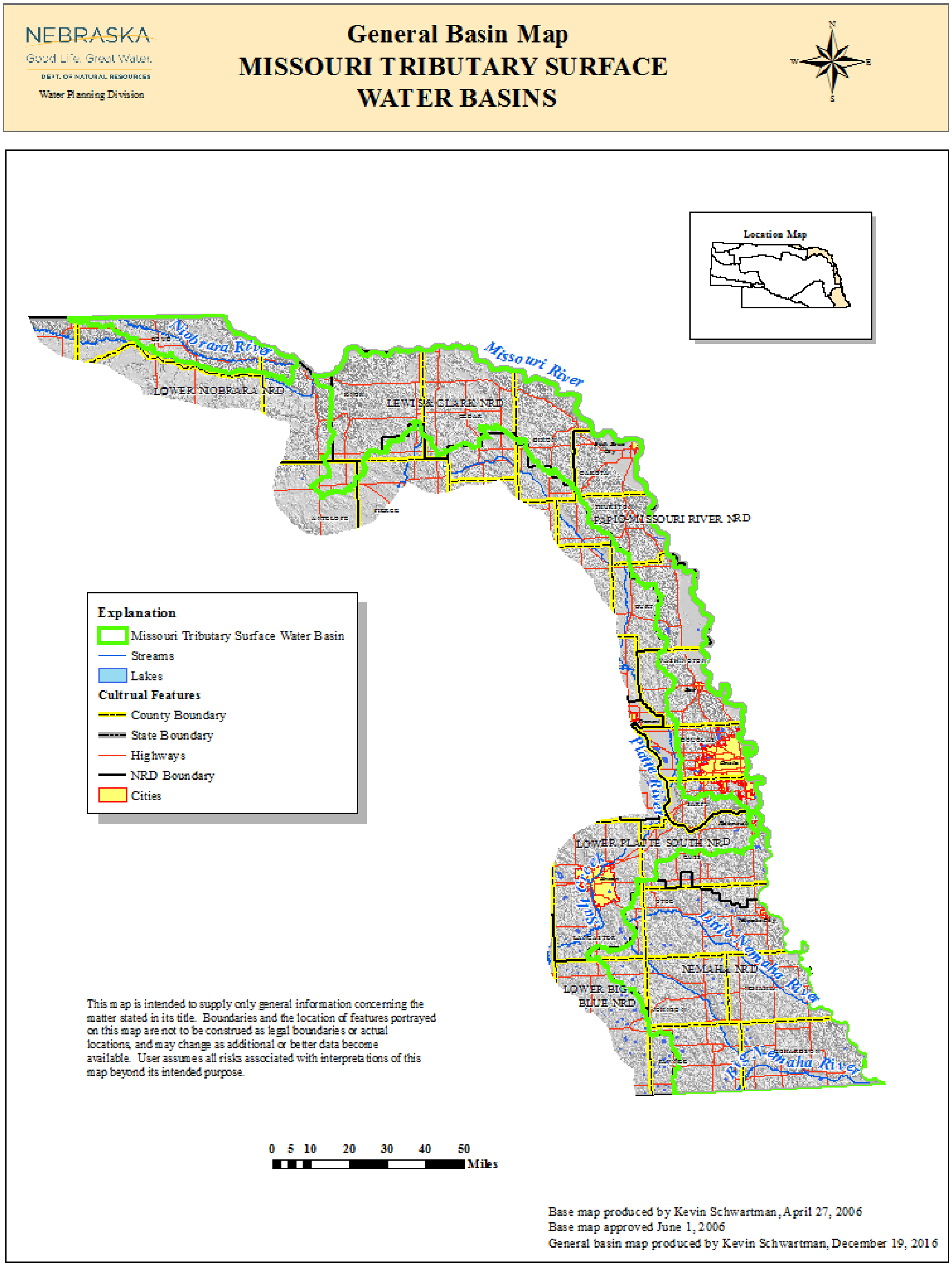

Figure 8-1. General basin map, Missouri Tributary Basins.

8.3 Nature and Extent of Water Use

8.3.1 Groundwater

Groundwater in the Missouri Tributary Basins is used for a variety of purposes including domestic, industrial, livestock, irrigation, and other uses. A total of 7,946 groundwater wells had been registered within the basins as of December 31, 2015 (Department registered groundwater wells database) (Figure 8-2). The locations of all active groundwater wells can be seen in Figure 8-3.

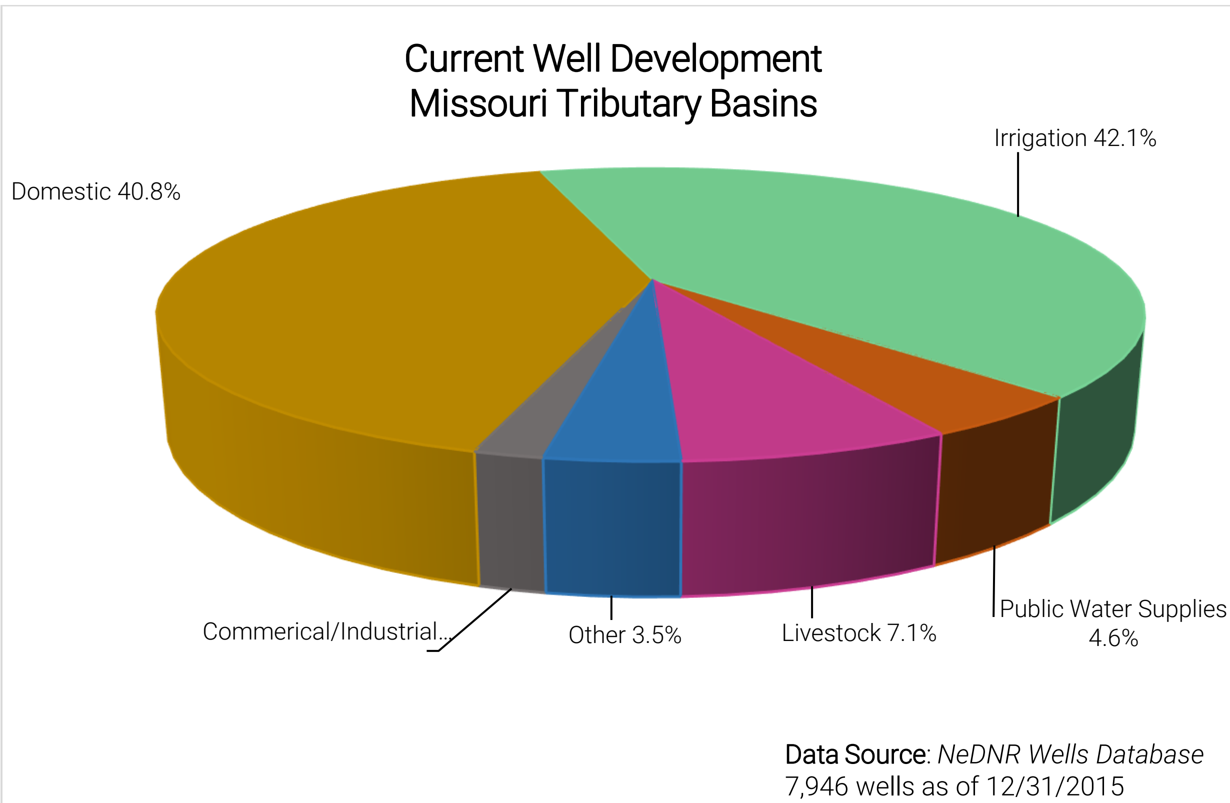

Figure 8-2. Current well development by number of registered wells, Missouri Tributary Basins.

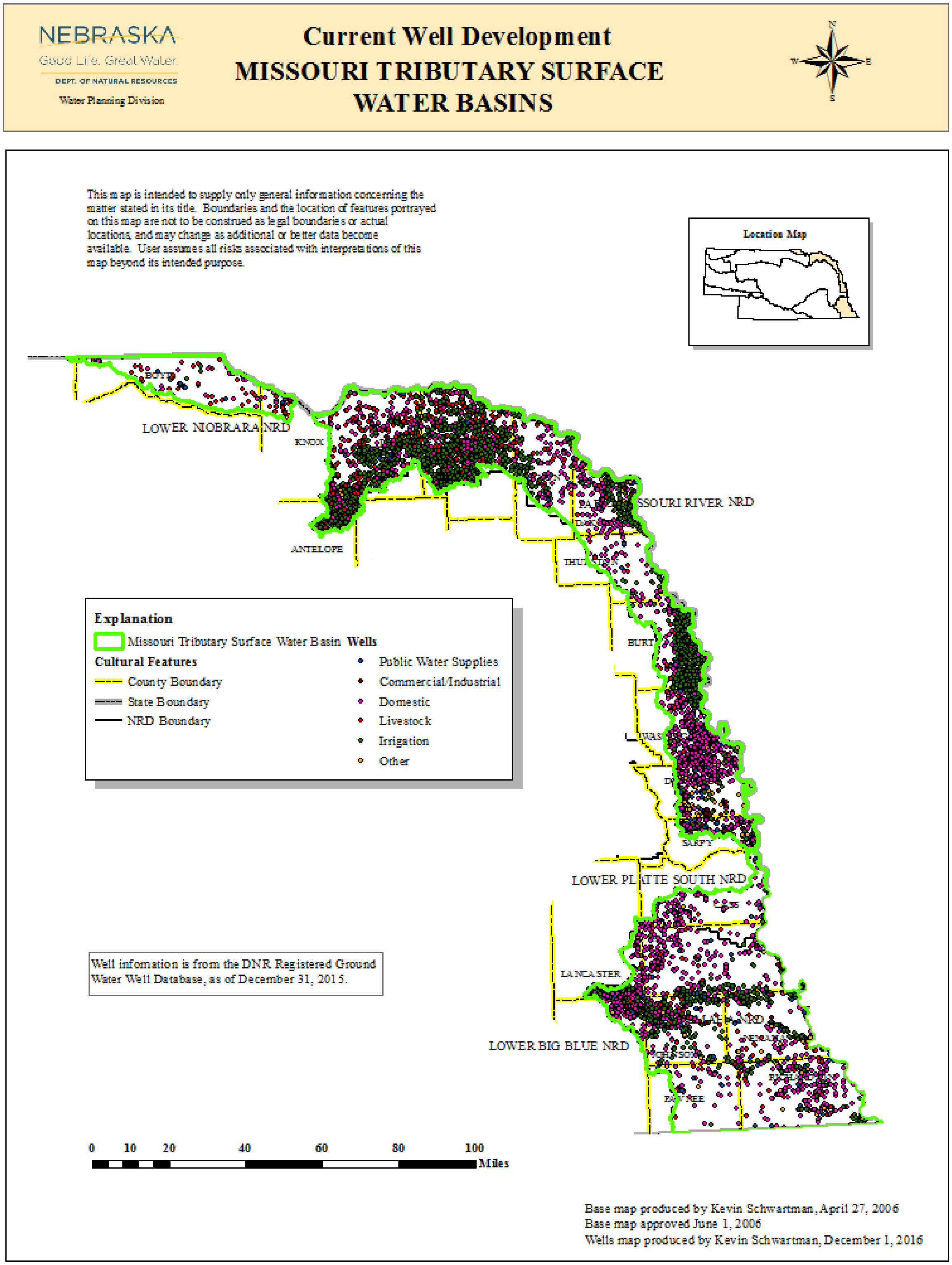

Figure 8-3. Current well locations, Missouri Tributary Basins.

8.3.2 Surface Water

As of December 31, 2015, 1,289 active surface water appropriations were held in the Missouri Tributary Basins, issued for a variety of uses (Figure 8-4). Most of the surface water appropriations are for storage and irrigation use and tend to be located on the major streams. The first surface water appropriations in the basins were permitted in 1881, and development has continued through the present day. The approximate locations of the surface water diversion points are shown in Figure 8-5.

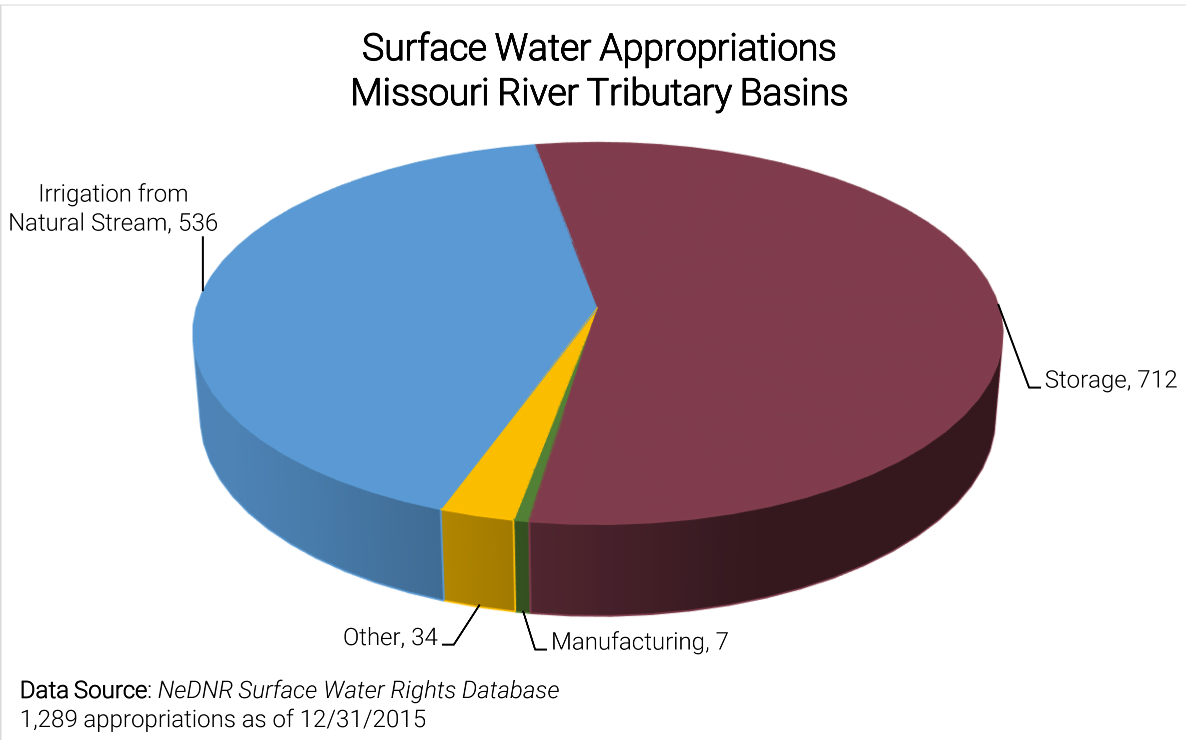

Figure 8-4. Surface water appropriations by number of diversion points, Missouri Tributary Basins.

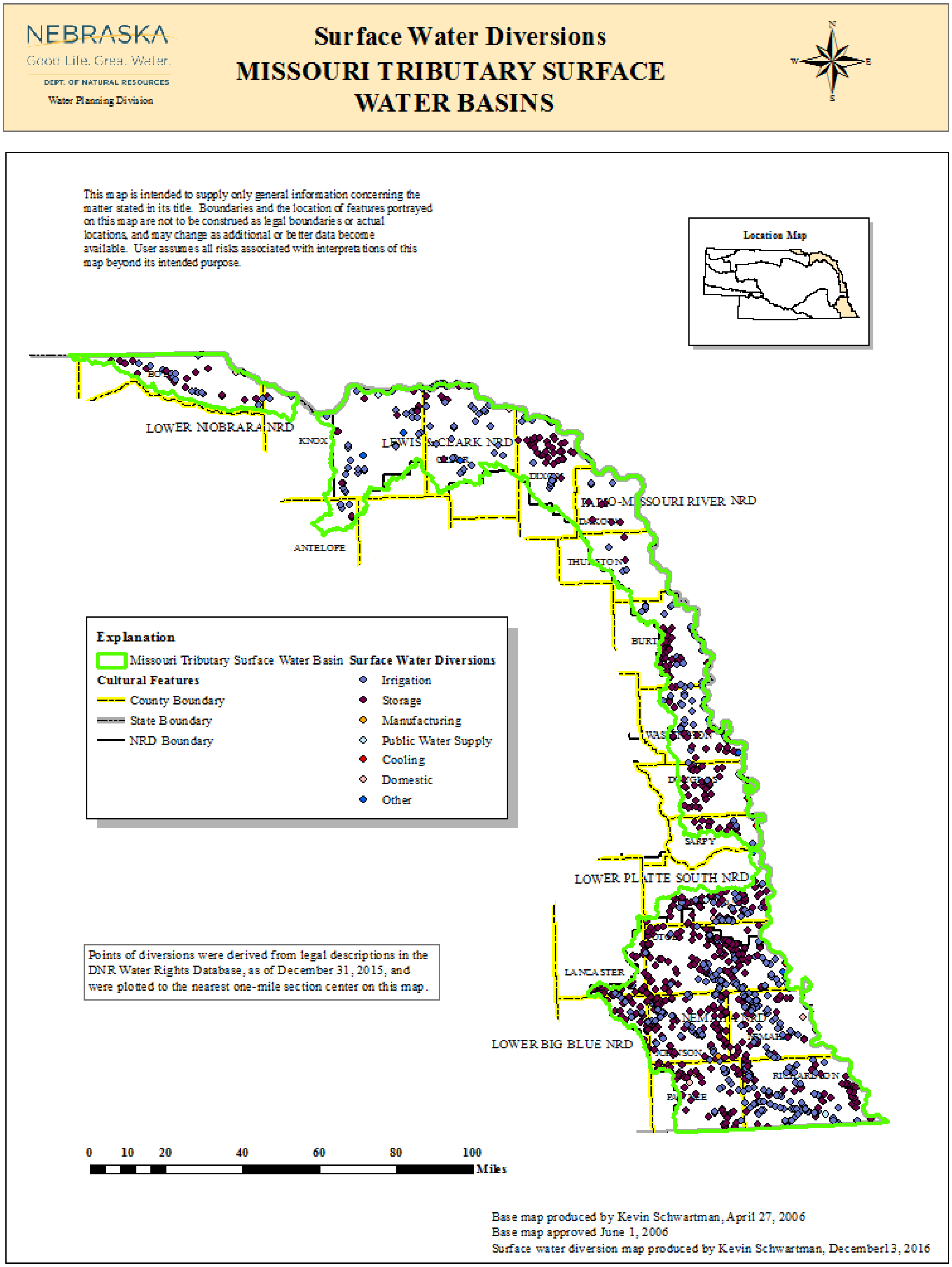

Figure 8-5. Surface water appropriation diversion locations, Missouri Tributary Basins.

8.4 Hydrologically Connected Area

No sufficient numeric groundwater model is currently available in the Missouri Tributary Basins to determine the 10/50 area. Much of the basins were glaciated, and in those areas the lack of sufficient data and/or appropriate hydrogeologic conditions does not allow for the use of the existing methodologies. The stream depletion factor (SDF) methodology can be applied only where sufficient data and appropriate hydrogeologic conditions exist. In most of the basins, the principal aquifer is absent or very thin due to the glaciated nature of the area. Additionally, where a principal aquifer is present, the complex hydrogeologic nature of the area makes the degree of connection between the groundwater system and the surface water system either poor or uncertain (CSD, 2005). The area surrounding the headwaters of Bazile Creek is the only portion of the basins where the principal aquifer is both present and known to be in hydrologic connection with the streams. Consequently, this is the only portion of the study area in which the 10/50 area was calculated (Figure 8-6).

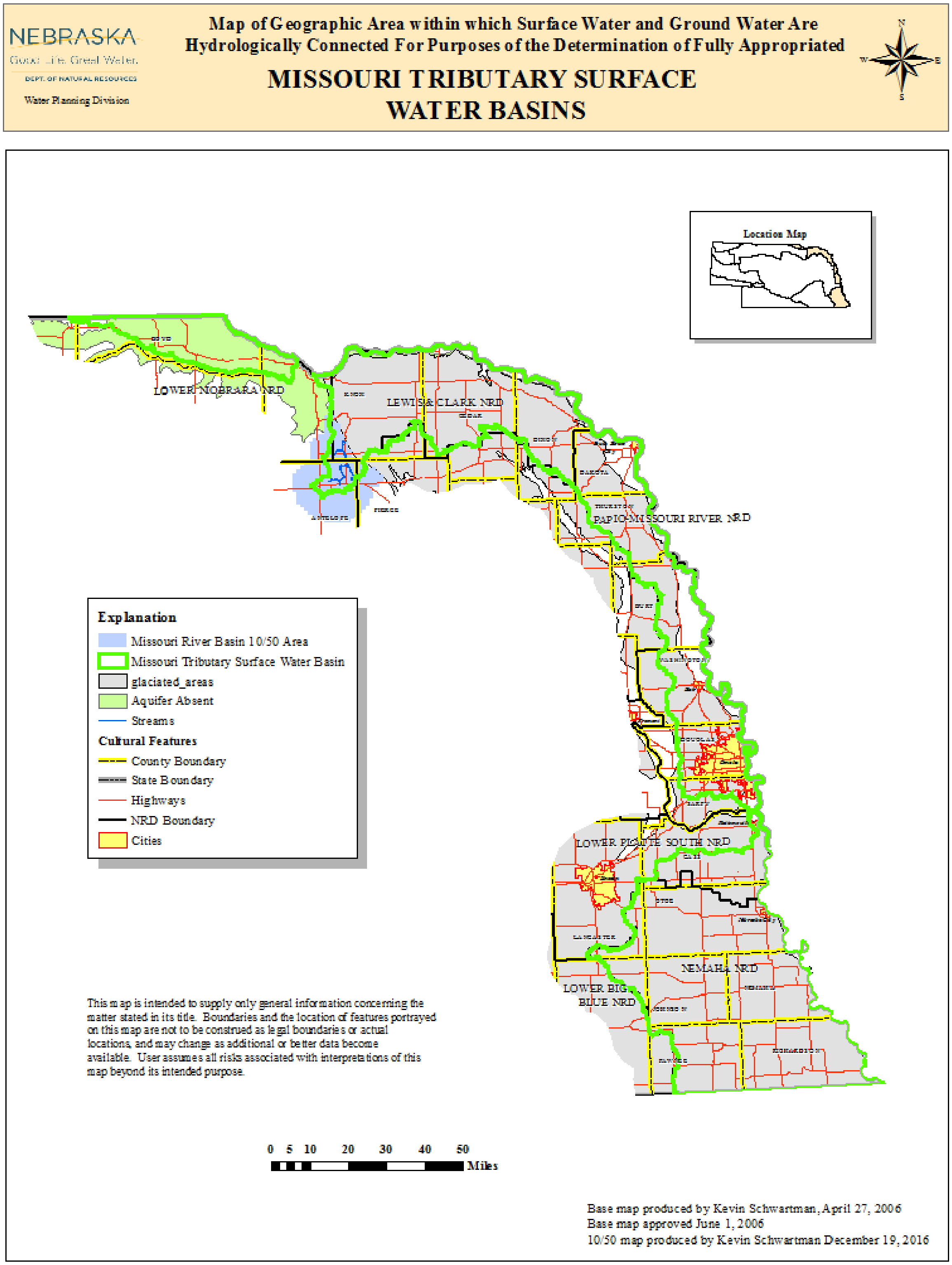

Figure 8-6. 10/50 area, Missouri Tributary Basins.

8.5 Net Corn Crop Irrigation Requirement

Figure 8-7 is a map of the net corn crop irrigation requirement (NCCIR) for the Missouri Tributary Basins (DNR 2005). The NCCIR in the basins ranges from 5.3 to 10.0 inches. To assess the number of days required to be available for diversion, a surface water diversion rate equal to 1 cfs per 70 acres, a downtime of 10 percent, and an irrigation efficiency of 80 percent were assumed. Based on these assumptions, it will take a junior surface water appropriation between 14.1 and 26.6 days annually to divert 65 percent of the NCCIR and between 18.4 and 34.7 days to divert 85 percent of the NCCIR.

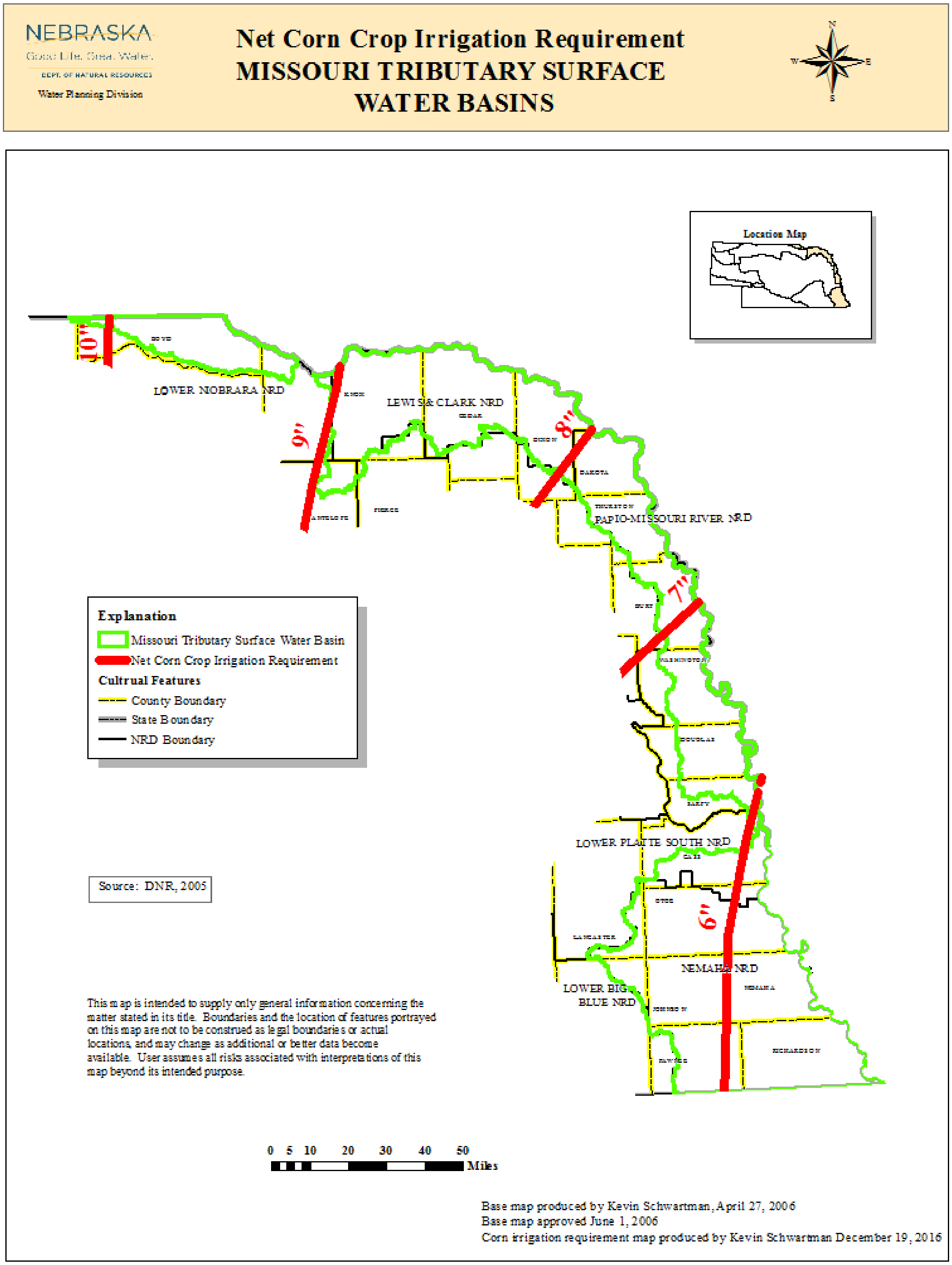

Figure 8-7. Net corn crop irrigation requirement (NCCIR), Missouri Tributary Basins.

8.6 Surface Water Closing Records

Table 8-1 records all surface water administration that has occurred in the Missouri Tributary Basins between 1996 and 2015.

Table 8-1. Surface water administration in the Missouri Tributary Basins, 1996-2015.

Year	Water Body	Days	Closing Date	Opening Date
2002	Weeping Water Creek	21	Jul 30	Aug 20
2004	Weeping Water Creek	3	Aug 23	Aug 26
2005	Weeping Water Creek	3	Jul 15	Jul 18

8.7 Evaluation of Current Development

8.7.1 Current Water Supply

The current water supply is estimated by using the most recent 20-year period (1996-2015) of surface water administration. The results of the analyses conducted for the Missouri Tributary Basins are shown in Table 8-2. The results indicate that the current surface water supply in the Missouri Tributary Basins provides an average of at least 60.6 days available for diversion between July 1 and August 31 and 151.7 days available for diversion between May 1 and September 30 (Table 8-3).

Table 8-2. Estimate of the current number of days surface water is available for diversion in the Missouri Tributary Basins.

Year	July 1 through August 31 Number of Days Surface Water is Available for Diversion	May 1 through September 30 Number of Days Surface Water is Available for Diversion
1996	62	153
1997	62	153
1998	62	153
1999	62	153
2000	62	153
2001	62	153
2002	41	132
2003	62	153
2004	59	150
2005	59	150
2006	62	153
2007	62	153
2008	62	153
2009	62	153
2010	62	153
2011	62	153
2012	62	153
2013	62	153
2014	62	153
2015	62	153
Average	60.6	151.7

Table 8-3. Comparison between the number of days required to meet the net corn crop irrigation requirement and number of days surface water is currently available for diversion in the Missouri Tributary Basins.

	Number of Days Necessary to Meet the 65% and 85% of Net Corn Crop Irrigation Requirement	Average Number of Days Available for Diversion with Current Development
July 1 – August 31 (65% Requirement)	14.1 to 26.6	60.6 or greater (at least 34.0 days above the requirement)
May 1 – September 30 (85% Requirement)	18.4 to 34.7	151.7 or greater (at least 117.0 days above the requirement)

8.7.2 Long-Term Water Supply

In order to complete the long-term evaluation of surface water supplies, a future 20-year water supply for the basins must be estimated. The Missouri Tributary Basins' water sources are precipitation, which runs off as direct streamflow and infiltrates into the ground to discharge as baseflow; and groundwater movement into the basins, which discharges as baseflow. Using methodology published in the *Journal of Hydrology* (Wen and Chen 2005), a nonparametric Mann-Kendall trend test of the weighted average precipitation in the basins was completed. The analysis showed no statistically significant trend in precipitation ($P > 0.95$) over the past 60 years (Figure 8-8); therefore, using the previous 20 years of streamflow data as the best estimate of the future surface water supply is a reasonable starting point for applying the lag depletions from groundwater wells.

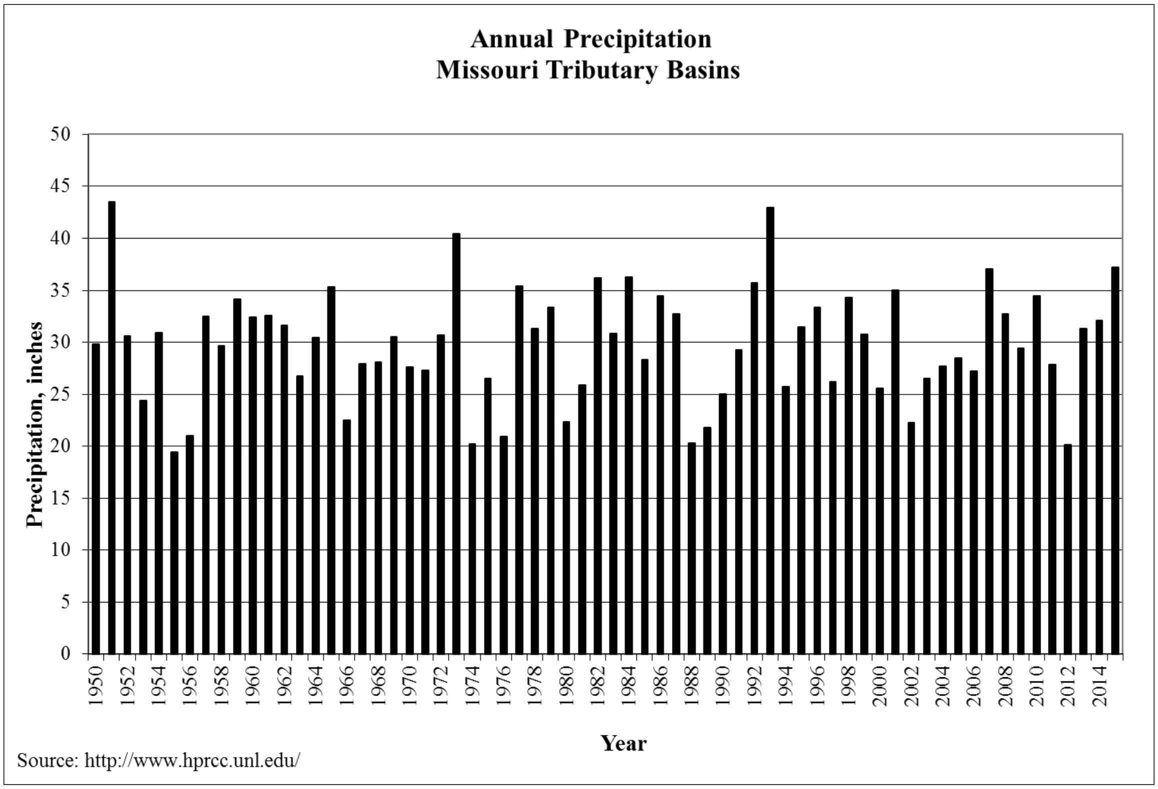

Figure 8-8. Annual precipitation, Missouri Tributary Basins.

8.7.3 Depletions Analysis

The future depletions due to current well development that could be expected to affect streamflow in the basins were estimated using the SDF methodology. The results estimate the future streamflows in the Bazile Creek subbasin to be depleted by 7 cfs in 25 years. For all other Missouri Tributary Basins, a lack of sufficient data and/or appropriate hydrogeologic conditions prohibited the use of the SDF methodology at this time.

8.7.4 Evaluation of Current Levels of Development against Future Water Supplies

The estimates of the 20-year average number of days available for diversion were not estimated for any of the Missouri Tributary Basins, including the Bazile Creek subbasin, because only minimal surface water administration has previously occurred in the basin, and the threshold flows necessary to satisfy senior appropriations could not be estimated.

Even though the future water supplies were not estimated, the current number of days in which surface water was available for diversion far exceeds the number of days necessary to meet the 65/85 rule.

8.8 Evaluation of Predicted Future Development

Estimates of the number of high capacity wells (wells pumping greater than 50 gpm) that would be completed over the next 25 years, if no new legal constraints on the construction of such wells were imposed, were calculated based on extrapolating the present-day rate of increase in well development into the future (Figure 8-9). The present-day rate of development is based on the linear trend of the previous 10 years of development. Based on the analysis of the past 10 years of development, the rate of increase in high capacity wells is estimated to be 40 wells per year in the Bazile Creek Basin.

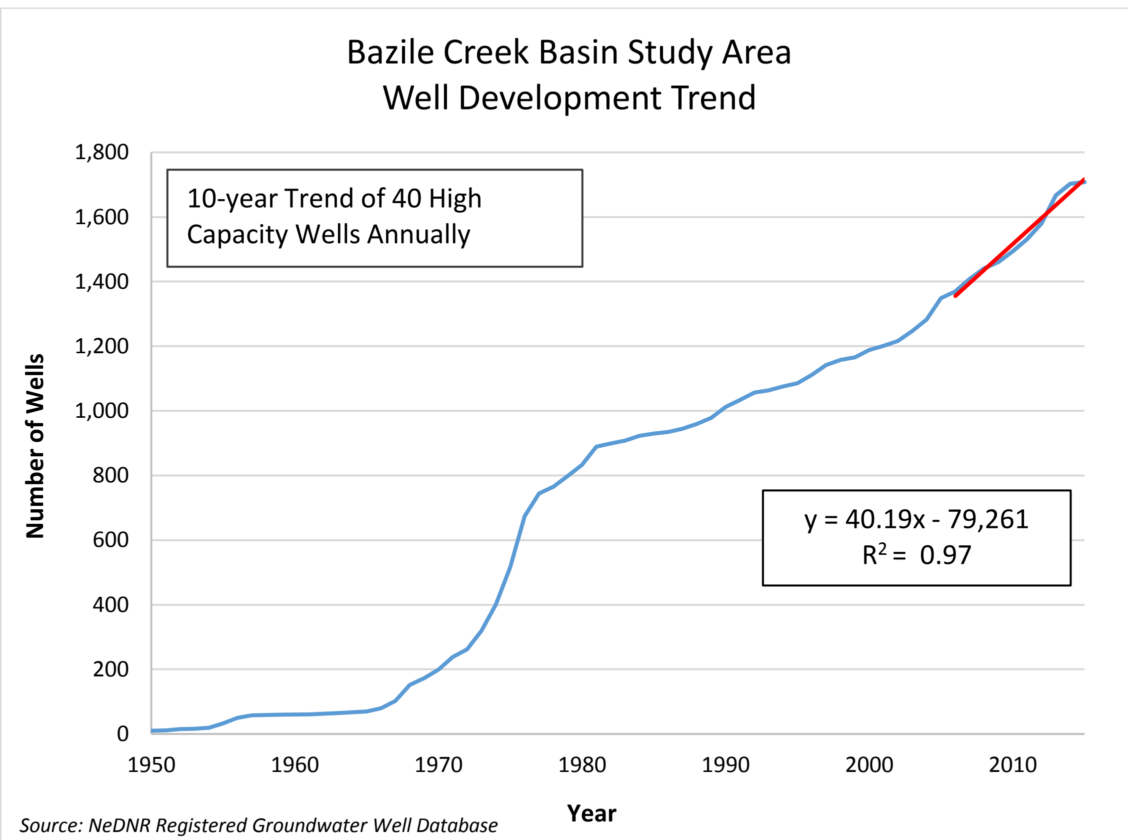

Figure 8-9. High capacity well development, Bazile Creek Basin.

The future depletions due to potential future well development that could be expected to affect streamflow in the Bazile Creek subbasin were estimated using the SDF methodology. The results estimate the future streamflow to be depleted by an additional 21 cfs in 25 years. Future depletions due to potential future well development were not estimated for all other Missouri Tributary Basins at this time due to a lack sufficient data and appropriate hydrogeologic conditions.

The estimate of the 20-year average number of days surface water is available for diversion was not calculated because minimal surface water administration has previously occurred and the threshold flows necessary to satisfy senior appropriations could not be estimated. Even though the future water supplies were not estimated, the current number of days in which surface water was available for diversion far exceeds the number of days necessary to meet the 65/85 rule.

8.9 Sufficiency to Avoid Noncompliance

There are no compacts on any portions of the Missouri Tributary Basins in Nebraska.

8.10 Groundwater Recharge Sufficiency

The streamflow is sufficient to sustain over the long-term the beneficial uses from wells constructed in aquifers dependent on recharge from the stream (Appendix F).

8.11 Current Studies Being Conducted to Assist with Future Analysis

An effort to categorize the aquifer characteristics and the water supply of the glaciated portion of eastern Nebraska, which includes large areas of the Missouri Tributary Basins, is continuing. This body of work will be reviewed by the Department to evaluate potential methods that may be developed to assess hydrologically connected areas and potential impacts of current and future development. Utilizing the Lower Platte Missouri Tributaries Model (north and central areas), the Department has completed the modeling and documentation portions of this work and is currently undergoing peer review. Modeling efforts of the Nemaha Model (southern area) are in its starting phase. Additionally, the Department and Lewis and Clark NRD have completed a voluntary integrated management plan.

8.12 Relevant Data Provided by Interested Parties

The Department published a request for relevant data from interested parties for this year's evaluation on November 23, 2016 (see Appendix B for affidavit). The Department did not receive any such information.

8.13 Conclusions

Based on the analysis of the sufficiency of the long-term surface water supply in the Missouri Tributary Basins, the Department has reached a preliminary conclusion that the basins are not fully appropriated under the current rule. The use of the SDF methodology to determine lag effects of current development requires sufficient data and appropriate hydrogeologic conditions. Those data and those conditions exist only in the Bazile Creek subbasin at this time. Therefore, lag effects of current development and potential future development were estimated only in the Bazile Creek subbasin.

The analysis of lag effects of current development for the Bazile Creek subbasin indicates a reduction in streamflow of 7 cfs in 25 years. The analysis of the impacts of future development on the Bazile Creek subbasin based on current development trends indicates an additional reduction in streamflow of 21 cfs in 25 years. The future number of days available to junior irrigators was not estimated because no surface water administration has occurred on the Bazile Creek subbasin in the past 20 years. Even though the future number of days available to junior irrigators was not estimated, the current number of days in which surface water was available for diversion far exceeds the number of days necessary to meet the net corn crop irrigation requirement (NCCIR).

Bibliography of Hydrogeologic References for Missouri Tributary River Basins

Conservation and Survey Division. 2005. *Mapping of Aquifer Properties-Transmissivity and Specific Yield-for Selected River Basins in Central and Eastern Nebraska.* Lincoln.

Nebraska Department of Natural Resources. 2005. *2006 Annual Evaluation of Availability of Hydrologically Connected Water Supplies*. Lincoln.

Wen, F.J. and X.H. Chen, 2006. Evaluation of the Impact of Groundwater Irrigation on Streamflow Depletion in Nebraska. *Journal of Hydrology,* 327: 603-617.

9.0 BASIN SUMMARIES AND RESULTS

9.1 Blue River Basins

The Blue River Basins are located in south-central Nebraska and consist of all of the surface areas that drain into the Big Blue River and the Little Blue River and all aquifers that impact surface water flows in the basins.

The Department has reached a preliminary conclusion that no portion of these basins is currently fully appropriated under the current rule. The analysis of lag depletions of current development for the Big Blue River Basin indicates a reduction in streamflow of 12 cfs in 25 years. The analysis of lag depletions of current development for the Little Blue River Basin indicates a reduction in streamflow of 17 cfs in 25 years. The analysis of the impacts of future development on the Big Blue River Basin based on current development trends indicates an additional reduction in streamflow of 3 cfs in 25 years. The analysis of the impacts of future development on the Little Blue River Basin based on current development trends indicates an additional reduction in streamflow of 10 cfs in 25 years.

The Department determined that the near-term and long-term availability of surface water for diversion for each basin exceeds the number of days necessary to meet 65 percent and 85 percent of the net corn crop irrigation requirement for the applicable time periods. The Department has also determined that based on current information, if no additional legal constraints are imposed on future development of hydrologically connected surface water and groundwater and reasonable projections are made about the extent and location of future development, this preliminary conclusion would not change to a conclusion that the basin is fully appropriated.

9.2 Lower Niobrara Basin

The Lower Niobrara River Basin is located in the northern portion of Nebraska and consists of all of the surface areas that drain into the Niobrara River downstream of the Mirage Flats Irrigation District and all aquifers that impact surface water flows of the basin.

The Upper Niobrara-White Model and CENEB Model were used to determine the 10/50 area and lag depletions due to current and projected future well development. The analysis of lag depletions of current development for the Lower Niobrara Basin indicates a reduction in streamflow of 29 cfs in 25 years. The analysis of the impacts of future development on the Lower Niobrara Basin based on current development trends indicates an additional reduction in streamflow of 84 cfs in 25 years.

The Department has reached a preliminary conclusion that no portion of the basin is fully appropriated under the current rule. The long-term availability of surface water for diversion exceeds the number of days necessary to meet 65 percent and 85 percent of the net corn crop irrigation requirement for the applicable time periods, and that the instream flow appropriations in the basin have not been eroded. The Department has also determined that based on current information, if no additional legal constraints are imposed on future development of hydrologically connected surface water and groundwater and reasonable projections are made about the extent and location of future development, this preliminary conclusion would not change to a conclusion that the basin is fully appropriated.

Although the basin has not been be determined to be fully appropriated using the methodology of the current rule, there may be times when supplies are not sufficient to meet all demands, as is shown by the Department's INSIGHT analysis. This is important for water managers to consider when developing a basin-wide plan or voluntary integrated management plan.

9.3 Lower Platte River Basin

The Lower Platte River Basin is located in the central and eastern portions of Nebraska and consists of all the surface water areas that drain into the Platte River from its confluence with the Loup River to its confluence with the Missouri River, including those areas that drain into the Loup River and the Elkhorn River, and all aquifers that impact surface water flows of the basin.

The Department utilized the CENEB model to perform calculations of 10/50 areas and depletions for the Loup River Basin and upper portions of the Elkhorn River Basin. No sufficient numerical groundwater model is available in the remaining portions of the Lower Platte River Basin; therefore, SDF methodology was used to determine the 10/50 area and depletions for those areas.

The analysis of the lag effects of current development indicates a reduction in streamflow by 337 cfs in 25 years. The analysis of the impacts of future development indicates an additional reduction in streamflow of 122 cfs in 25 years.

The Department has reached a preliminary conclusion that no portion of the basin is fully appropriated under the current rule. The long-term availability of surface water for diversion exceeds the number of days necessary to meet 65 percent and 85 percent of the net corn crop irrigation requirement for the applicable time periods, and that the instream flow appropriations in the basin (the junior rights for which administration occurs in the non-irrigation season) have not been eroded. The Department has also determined that based on current information, if no additional legal constraints are imposed on future development of hydrologically connected surface water and groundwater and reasonable projections are made about the extent and location of future development, this preliminary conclusion would not change to a conclusion that the basin is fully appropriated.

Although the basin has not been be determined to be fully appropriated using the methodology of the current rule, there may be times when supplies within a subbasin are not sufficient to meet all demands within that subbasin, as is shown by the Department's INSIGHT analysis. This is important for water managers to consider when developing a basin-wide plan or voluntary integrated management plan.

9.4 Missouri Tributary Basins

The Missouri Tributary Basins are located in the north-central and eastern portions of Nebraska and consist of all of the surface areas that drain directly into the Missouri River, with the exception of the Niobrara River and Platte River basins, and all aquifers that impact surface water flows of the basins.

No sufficient numerical groundwater model is available in the Missouri Tributary Basins to determine the 10/50 area. Much of the basins were glaciated and in those areas, the lack of sufficient data and/or appropriate hydrogeologic conditions does not allow for the use of the existing methodologies. Therefore, the Department was unable to delineate the 10/50 area for the glaciated portions of the basins. The non-glaciated area surrounding the headwaters of Bazile Creek is the only portion of the basins where the principal aquifer is both present and in hydrologic connection with the streams; therefore, the 10/50 area was delineated using the SDF methodology for that portion of the Missouri Tributary Basins only.

The analysis of lag effects of current and potential future development was only conducted in the Bazile Creek subbasin due to a lack of sufficient data or appropriate hydrogeologic conditions in all other areas. The analysis of the Bazile Creek subbasin indicates a reduction in streamflow by 7 cfs in 25 years. The analysis of the impacts of future development on the Bazile Creek subbasin based on current development trends indicates an additional reduction in streamflow of 21 cfs in 25 years.

The Department has reached a preliminary conclusion that no portion of the Missouri River Tributary Basins is fully appropriated under the current rule. The near-term availability of surface water for diversion exceeds the number of days necessary to meet 65 percent and 85 percent of the net corn crop irrigation requirement for the applicable time periods. Estimates of future water supplies for junior irrigators in the Bazile Creek subbasin could not be estimated due to limited surface water administration during the past 20 years. For all other subbasins, the inability to calculate the lag effects of existing and future groundwater development prohibited a determination of future water supplies for junior irrigators at this time. Even though the long-term water supplies were not estimated, the current number of days in which surface water was available for diversion far exceeds the number of days necessary to meet the 65/85 rule.

9.5 Results of Analyses

Tables 9-1 and 9-2 summarize the results of the analysis for sufficiency of water availability for irrigation in each basin.

Table 9-1. Summary of comparison between the number of days required to meet 65 percent of the net corn crop irrigation requirement and number of days in which surface water is available for diversion, July 1 – August 31.

	Days Necessary to Meet 65% of Net Corn Crop Irrigation Requirement	Average Number of Days Available for Diversion at Current Development	Average Number of Days Available for Diversion at Current Development with 25 Years of Lag Impacts	Average Number of Days Available for Diversion with Future Development and 25 Years of Lag Impacts
Big Blue River Basin	23.9	49.9	48.4	48.2
Little Blue River Basin	25.7	53.5	51.2	49.1
Lower Niobrara River Basin	23.6 – 36.9	43.0	42.9	42.7
Lower Platte River Basin upstream of North Bend, including the Loup River Basin	27.9	42.2	40.3	39.1
Lower Platte River Basin downstream of North Bend and upstream of Louisville including the Elkhorn River Basin	27.9	43.1	40.7	39.8
Missouri Tributary Basins	14.1 – 26.6	60.6	Not Calculated [c]	Not Calculated [c]

Table 9-2. Summary of comparison between the number of days required to meet 85 percent of the net corn crop irrigation requirement and number of days in which surface water is available for diversion, May 1 – September 30.

	Days Necessary to Meet 85% of Net Corn Crop Irrigation Requirement	Average Number of Days Available for Diversion at Current Development	Average Number of Days Available for Diversion at Current Development with 25 Years of Lag Impacts	Average Number of Days Available for Diversion with Future Development and 25 Years of Lag Impacts
Big Blue River Basin	31.3	138.6	137.0	136.8
Little Blue River Basin	33.6	141.0	135.4	132.0
Lower Niobrara River Basin	30.9 – 48.3	115.5	115.0	111.9
Lower Platte River Basin upstream of North Bend, including the Loup River Basin	36.5	119.4	116.2	114.0
Lower Platte River Basin downstream of North Bend and upstream of Louisville including the Elkhorn River Basin	36.5	120.8	117.0	115.5
Missouri Tributary Basins	18.4 – 34.7	151.7	Not Calculated [c]	Not Calculated [c]