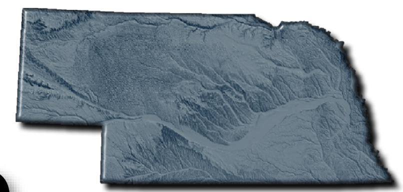
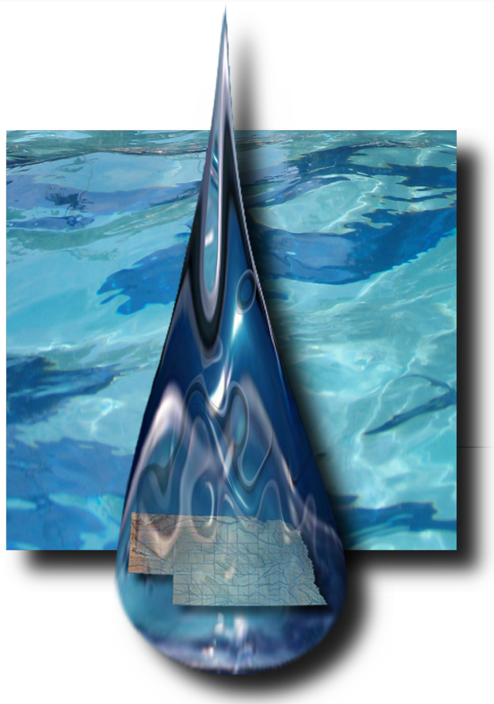
Nebraska Department of Natural Resources





2009 Annual Evaluation of Availability of Hydrologically Connected Water Supplies

Determination of Fully Appropriated

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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 B. 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 ground water and surface water (i.e., the “10/50 area”), conclusions about the adequacy of the long-term water supply, and whether the 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 Department of Natural Resources (Department) has evaluated the expected long-term availability of surface water supplies and hydrologically connected ground water supplies of the Blue River basins, the lower portion of the Niobrara River Basin, Lower Platte River Basin, and Missouri Tributary basins. The results of this evaluation show that the Blue River basins, Missouri Tributary basins, lower portion of the Niobrara River Basin, and the Lower Platte River Basin are not fully appropriated at the present time. Analysis of future water supplies in the Lower Platte River Basin indicates that, if no additional constraints are placed on ground water 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 cause the basin to become fully appropriated in the future.

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 46-753). 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 either initiated the development of an integrated management plan (IMP) or implemented an IMP. No reevaluations were made in this report for basins, subbasins, or reaches that have previously been determined to be fully or overappropriated.

The evaluation and 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 law, the report also describes the nature and extent of present water uses in the basin, shows the geographic area considered to have hydrologically connected surface water and ground water supplies, and predicts how the Department's conclusions might change if no new legal restrictions are placed on water development in the basin. The report does not address the sufficiency of ground water supplies that are not hydrologically connected to surface water streams. The report includes a description of the criteria and methodologies used to determine which 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 ground water uses on resources that are dependent on streamflow or ground water levels but that are not protected by appropriations or regulations. Appendix A 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 ground water users, and water transfers/water banking. The forty-nine Task Force members, appointed by the Governor 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 recommendations. Governor Mike 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 ground water users. Where conflicts already exist, it establishes 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 updates a number of individual water management statutes.

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

- Certain river basins were declared to be fully appropriated or overappropriated. The law automatically placed into fully appropriated status any natural resources district undertaking any integrated management process under previous law for integrated management of hydrologically connected ground water and surface water.

- Portions of the Platte River Basin were declared overappropriated by the legislature because the level of water resources development is not sustainable over the long term.

- 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 also 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 declared overappropriated or determined to be fully appropriated, stays on new uses of ground water and surface water are automatically to be imposed. The Department and the natural resources districts (NRDs) involved are required to develop and implement jointly an integrated management plan (IMP) within three to five years of that designation.

- A key goal of each IMP must be to manage all hydrologically connected ground water 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 reduction in current levels of water use so that it is possible to achieve a balance between water uses and water supplies.

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

- If disputes between the Department and the NRDs 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.

Since the passage of LB 962, a number of basins, subbasins, or reaches have been designated as fully or overappropriated (figures 2-1 and 2-2). Previous statutorily required reports on the evaluation of hydrologically connected water supplies are available online (http://www.dnr.ne.gov/docs/studiesandresearch.html) or upon request from the Department. This volume is the fourth statutorily required annual report.

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

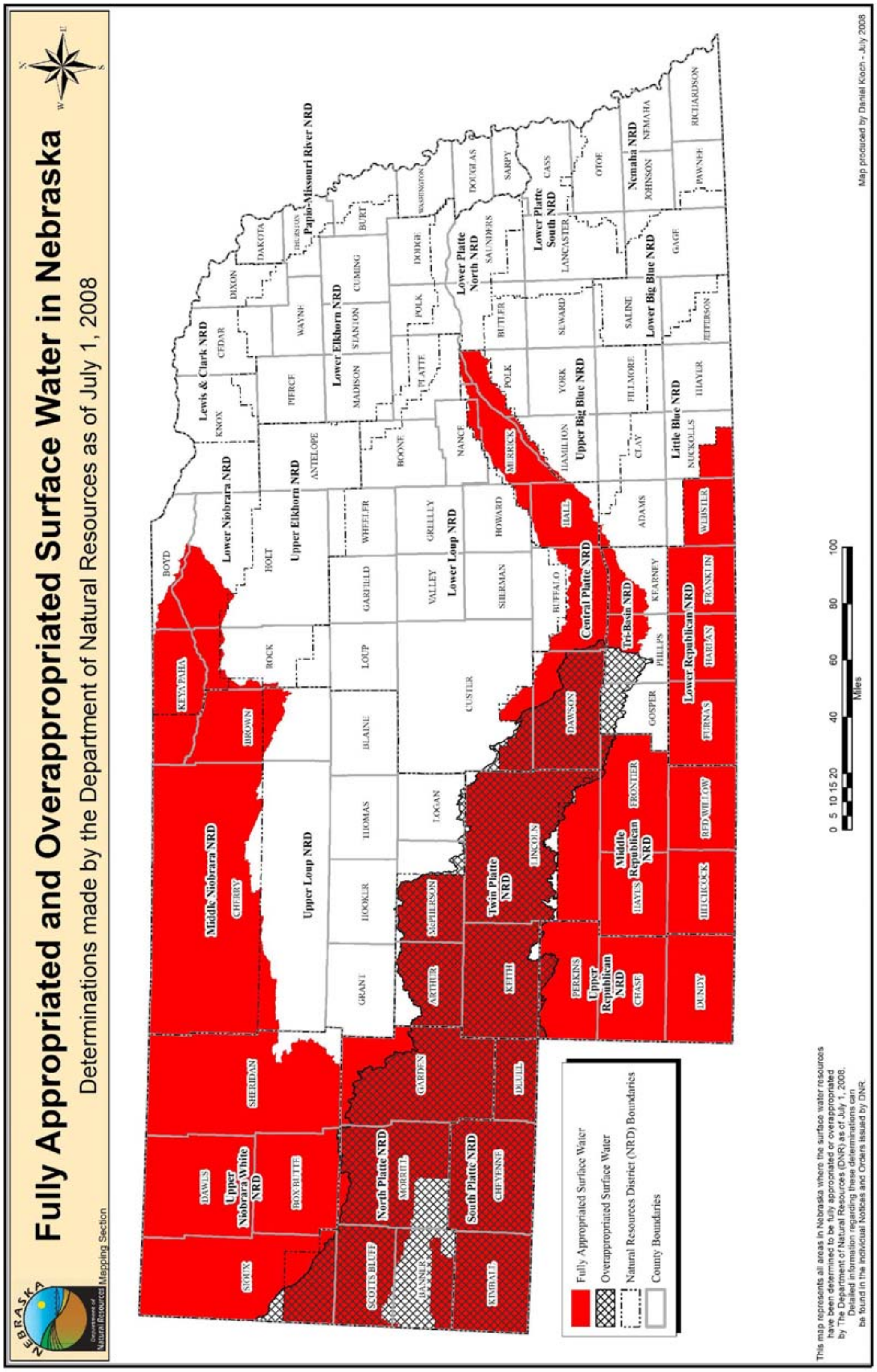
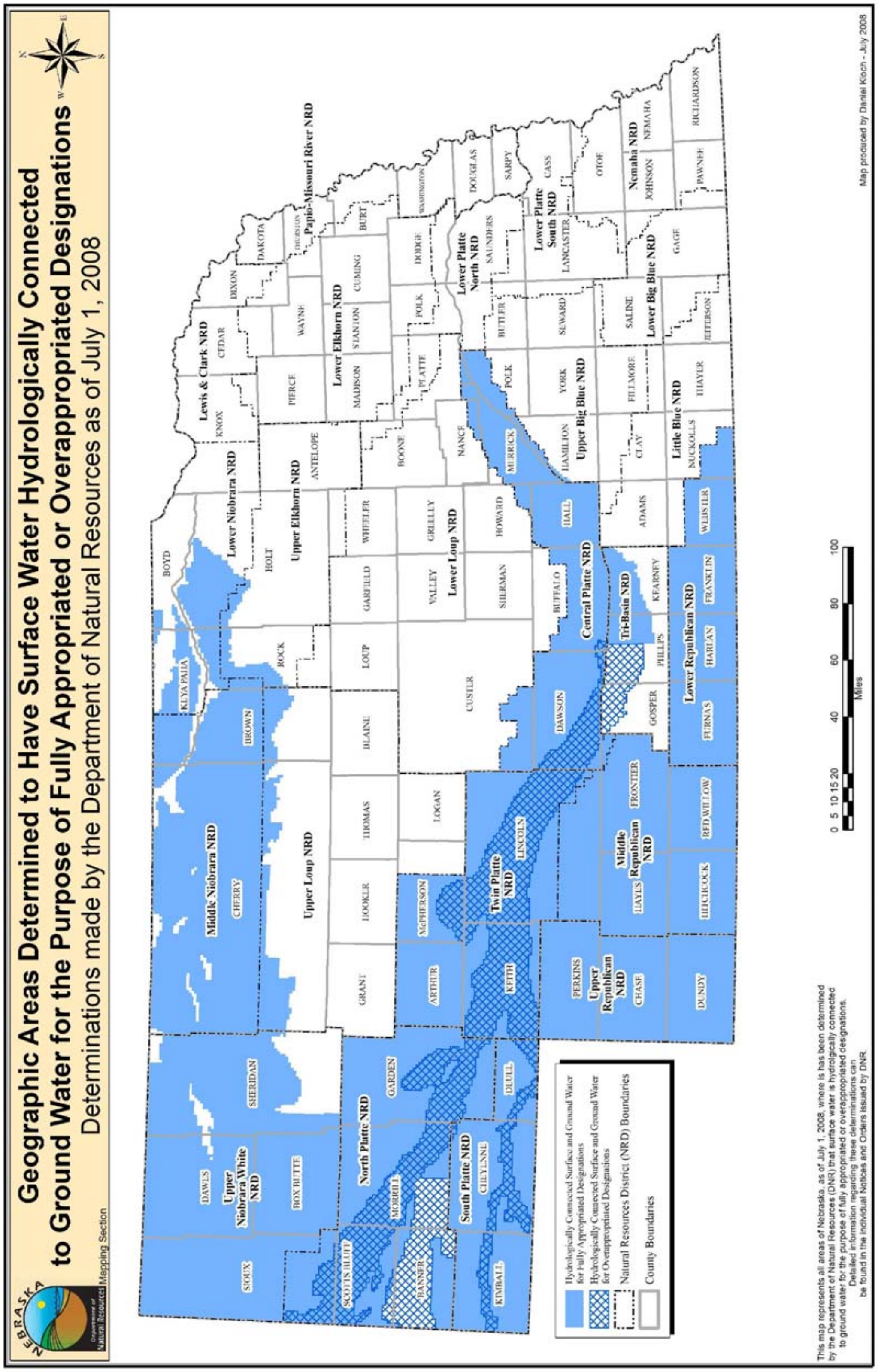


Figure 2-2 Areas designated as hydrologically connected to fully appropriated or overappropriated basins, subbasins, and reaches since the passage of LB 962.



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 the surface water in the watershed or catchment that runs off to the stream and the ground water that is in hydrologic connection with the stream. For all evaluated basins, the geographic areas of hydrologically connected surface water and ground water, where present, are shown on a basin-wide map that is included in each basin subsection. On each of those maps, the surface watershed basin is shown by a solid line, and the hydrologically connected ground water 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 N.A.C. 24.001.02, the Department considers the area within which ground water is hydrologically connected to a stream to be that area in which "pumping of a well for 50 years will deplete a river or base flow tributary thereof by at least 10% 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. Only those basins that have not initiated development of or implemented an IMP are required to be evaluated.

In preparing its annual report, the Department is required by section 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 uses can be found in rule 457 N.A.C. 24.002 (Appendix B). The Department is also required to provide enough documentation in the report to allow others to replicate and assess the Department's data, information, methodologies, and conclusions independently. That documentation can be found throughout the report. The raw data used for these calculations and the spreadsheets with the calculations will be provided by the Department upon request.

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

As a result of its annual evaluation, the Department is to arrive at a 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 conclusions would change if no additional legal constraints were imposed on future development of hydrologically connected surface water and ground water. 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 ground water 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 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) and by degrading or destroying a species' habitat so much that the species cannot survive (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, but state law is not clear as to whether the degradation of a species' habitat is also considered a taking. 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 its final determination, 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

Overview

This section provides an overview of the methodologies used in the Department's basin evaluations and is separated into four subsections. The first subsection will outline the legal requirements established in section 46-713 of the Ground Water Management and Protection Act and regulation 457 N.A.C. 24.001 (Appendix B) as they relate to the analysis. Subsection two will discuss the various methods available to assess stream depletions in hydrologically connected regimes and explain when specific methods were implemented by the Department. Subsection three will discuss the specific methods implemented by the Department to calculate the extent of the 10/50 area. The fourth subsection will proceed through the steps used in the evaluation of each basin.

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 ground water uses in each river basin, subbasin, or reach; 2) define the geographic area within which surface water and ground water 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 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 ground water uses is developed based on information obtained through published reports from the University of Nebraska-Conservation and Survey Division (CSD), the U.S. Geological Survey (USGS), natural resources districts, Department databases, and other sources as noted in the text. The 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 UNL-Conservation and Survey Division and U.S. Geological Survey websites, http://snr.unl.edu/csd/ and http://waterdata.usgs.gov/ne/nwis/gw, respectively. All data utilized in this report are available from the Department upon request.

The Department is tasked with assessing the geographic area within which surface water and ground water are hydrologically connected. Regulation 457 N.A.C. 24.001.02 states that the geographic area within which the ground water 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% of the amount of water the well could pump over a fifty-year period (i.e., "the 10/50 area").

The Department's evaluation of the extent to which current uses will affect available near-term and long-term water supplies considers current well development and the twenty-five-year lag impacts from that current 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 the associated impact on surface water appropriations.

The Department is also required to assess how its 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 twenty-five years. In projecting the quantity of wells that may be added to the number of currently developed wells, the Department considers the following: 1) availability of lands suitable for irrigation; 2) well-construction moratoriums established by natural resources districts; and 3) trends in well development over the previous ten-year period.

4.1.2 Regulation 457 N.A.C. 24.001

Regulation 457 N.A.C. 24.001 generally states that a basin is fully appropriated if current uses of hydrologically connected surface water and ground water 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 N.A.C. 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 twenty years to provide 85% of the amount of water a corn crop needs (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% 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 conclusion of whether a basin is fully appropriated is to apply what has been termed the "erosion rule" (457 N.A.C. 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 N.A.C. 24.001.01B, in the event that the junior water right is not an irrigation right, the Department will utilize 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.

4.2 Methods Available for Assessing Stream Depletions

Several methods are available for estimating the extent and magnitude of stream depletions. Historically, three broad categories have been used to study ground water flow systems - 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 ground water flow. 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.

4.2.1 Numerical Modeling Methods

With user-friendly interfaces and high-speed computers, numerical models have fast become the preferred method of evaluating regional ground water flow. One widely used numerical model developed by the U.S. Geological Survey is MODFLOW (McDonald and Harbaugh, 1988). For the purposes of this report, if an acceptable MODFLOW model suitable for regional analysis is available, then it will be utilized to assist in analysis. The areas for which an existing model was utilized in this year's evaluation were the Blue basins, Loup Basin, and portions of the Elkhorn Basin.

The remaining basins discussed in this report are not currently represented in a suitable numerical model. Development of a numerical model requires a substantial amount of quality-assured data. Current data collection efforts may allow for suitable model development for these basins in the future. At present, however, analytical methods are the best available tool for the analysis of stream depletions within these basins.

4.2.2 Analytical Methods

Analytical methods for the analysis of streamflow depletions have been developed by Glover and Balmer (1954), Maasland and Bittinger (1963), Gautuschi (1964), and others to evaluate the impacts of wells on streams. The Jenkins (1968) method for calculation of stream depletion factors (SDF) (Appendix C) lends itself best to the basin-wide aspect of the task described by this report. This method is based on simplifying assumptions and was built upon previously published equations. The Jenkins method has been utilized by other states, including Colorado and Wyoming, for water administration purposes. For this report, the Jenkins method was used in the evaluation of the Lower Niobrara River Basin, portions of the Lower Platte River Basin, and Missouri Tributary basins.

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 (Zlotnik, 2004). These modified methods, however, require additional data that are generally not available for the basins in this evaluation. The dominant factors in determining the impact of a pumping well on a stream are the distance of the well from the stream and the length of time that the well is pumped. Thus, the impact of any other differences between actual hydrologic and geologic conditions and the idealized assumptions used in the Jenkins method decreases as the distance from the stream and any relevant boundary conditions and duration of pumping increase. Therefore, when looking at regional impacts, the simplifying assumptions of the Jenkins method are much less significant. For this reason, and because of a lack of published data necessary for the calculations, no modifications were made to the Jenkins method for the Department's analysis.

In some areas of the state, particularly in the glaciated eastern sections, information regarding hydrologic conditions is inadequate, and no method currently available can be used to determine the 10/50 area or the lag impact of ground water pumping from wells. These areas were not evaluated in the current report.

4.3 Development of the 10/50 Areas

The 10/50 area is defined as the geographic area within which ground water is hydrologically connected to surface water. A well constructed in the 10/50 area would deplete river flow by at least 10% of the water pumped over a fifty-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 Use of Numerical Models

The Department reviewed available numerical models to assess their validity in defining the 10/50 area, predicting future lag impacts, and impacts from additional future development. Two models were identified as being qualified for use in this report. The Elkhorn-Loup model was developed through a joint partnership of various natural resources districts, the U.S. Geological Survey, and the Department. The Elkhorn-Loup model was used to define the extent of the 10/50 area and predict future lag impacts from current well development and projected future development for the Loup Basin and portions of the Elkhorn Basin. The Upper Big Blue Natural Resources District developed a numerical MODFLOW ground water model using Cooperative Hydrology Study (COHYST) data to delineate the extent of the 10/50 area hydrologically connected to the Little Blue River. Documentation for both of these ground water models is available in Appendix E.

4.3.2 Use of Analytical Methods

In areas where an acceptable numerical model has not been developed but where sufficient geologic data exist, (portions of the Lower Platte Basin, Missouri Tributaries basins, and Lower Niobrara Basin) the Jenkins SDF 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 Jenkins SDF calculations to delineate the 10/50 boundary for these basins.
4. Develop the 10/50 area.

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.

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 available from the U.S. Geological Survey National Hydrography Dataset. The main stems of each river and of its 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 which 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). Other supporting evidence from published reports was also used in some cases to delineate the extent of hydrologic connection between aquifers and streams, and this information is referenced where used.

Step 3: Perform Jenkins SDF Calculations

The Jenkins SDF method utilizes the following two terms, for which solutions are derived graphically using the curve shown in Figure 4-1.

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

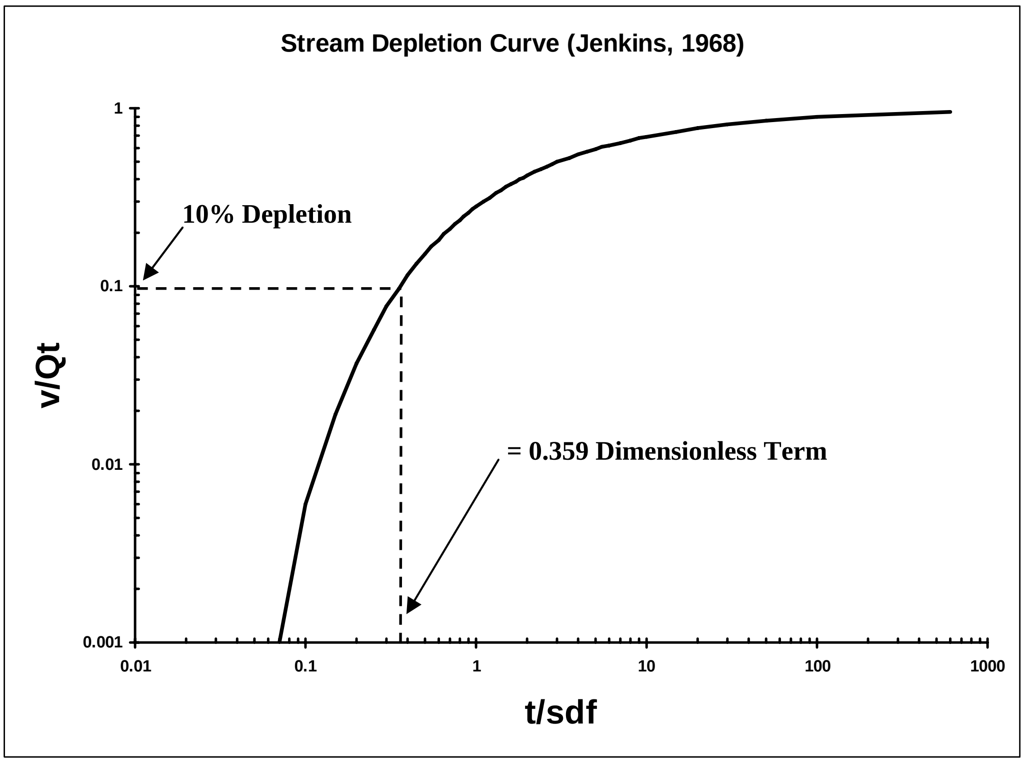
$$sdf = \frac{a^2 * S}{T}$$

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 4-1 Stream depletion curve from Jenkins (1968).

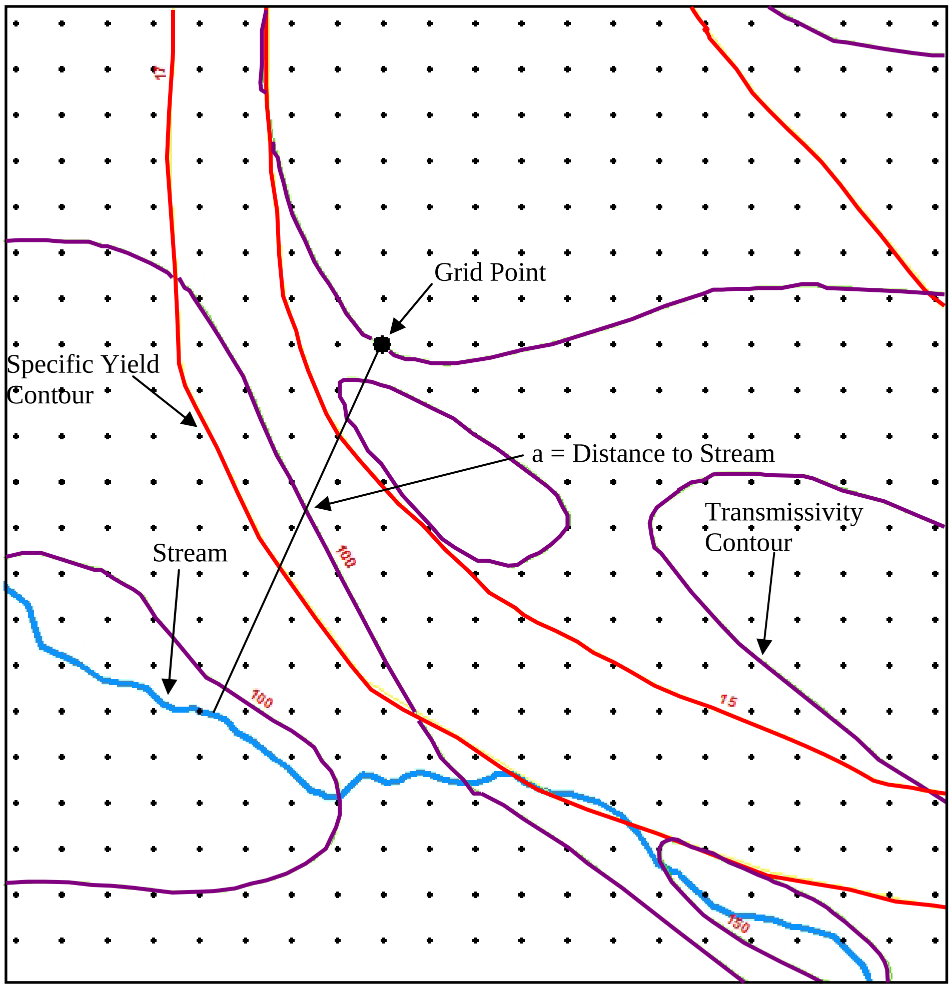


As illustrated in Figure 4-1, the dimensionless term will equal 0.359 when the depletion percentage is equal to 10%. The aquifer properties at each grid point and the distance of each grid point from the nearest perennial stream will be utilized to calculate the dimensionless term (Figure 4-2).

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 4-2 An example of the data and method used in determination of the 10/50 area.



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.

4.4 Evaluating the Status of a Basin

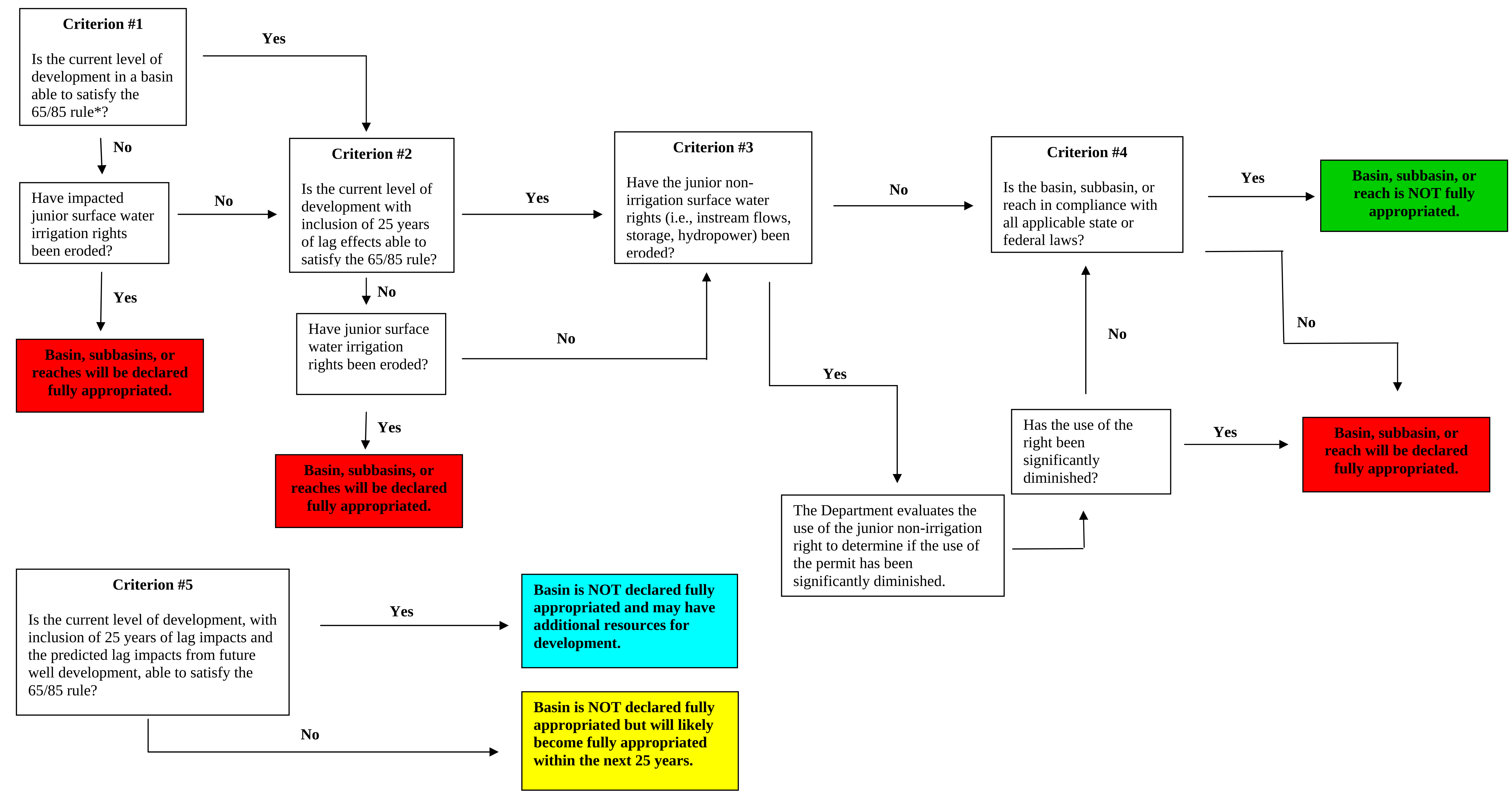
When determining the status of a basin, the Department evaluates five criteria: 1) that current levels of surface water and ground water development, without consideration of lag impacts from wells, are able to satisfy the 65/85 rule; 2) that current levels of surface water and ground water development,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

If criteria one and/or two are unable to be 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 appropriation has been eroded. Methods for implementation of the erosion rule are discussed in detail in Section 4.4.5. Figure 4-3 illustrates the evaluation process for determining whether a basin is fully appropriated.

Figure 4-3 Basin evaluation flow chart.

Evaluation of the Status of a Basin

Future Development



***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 twenty years to provide 85% 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% of the amount of water a corn crop needs during the key growing period of July 1 through August 31.**

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.

4.4.1 The Role of Surface Water Administration Doctrine

The administration of surface water plays a key role in evaluating the sustainability of development within 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 not feasible to predict the point 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, the Department analyzed the water available to the most junior appropriator in each basin evaluation. 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.

4.4.2 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 twenty-year period of streamflows (1988-2007). 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.

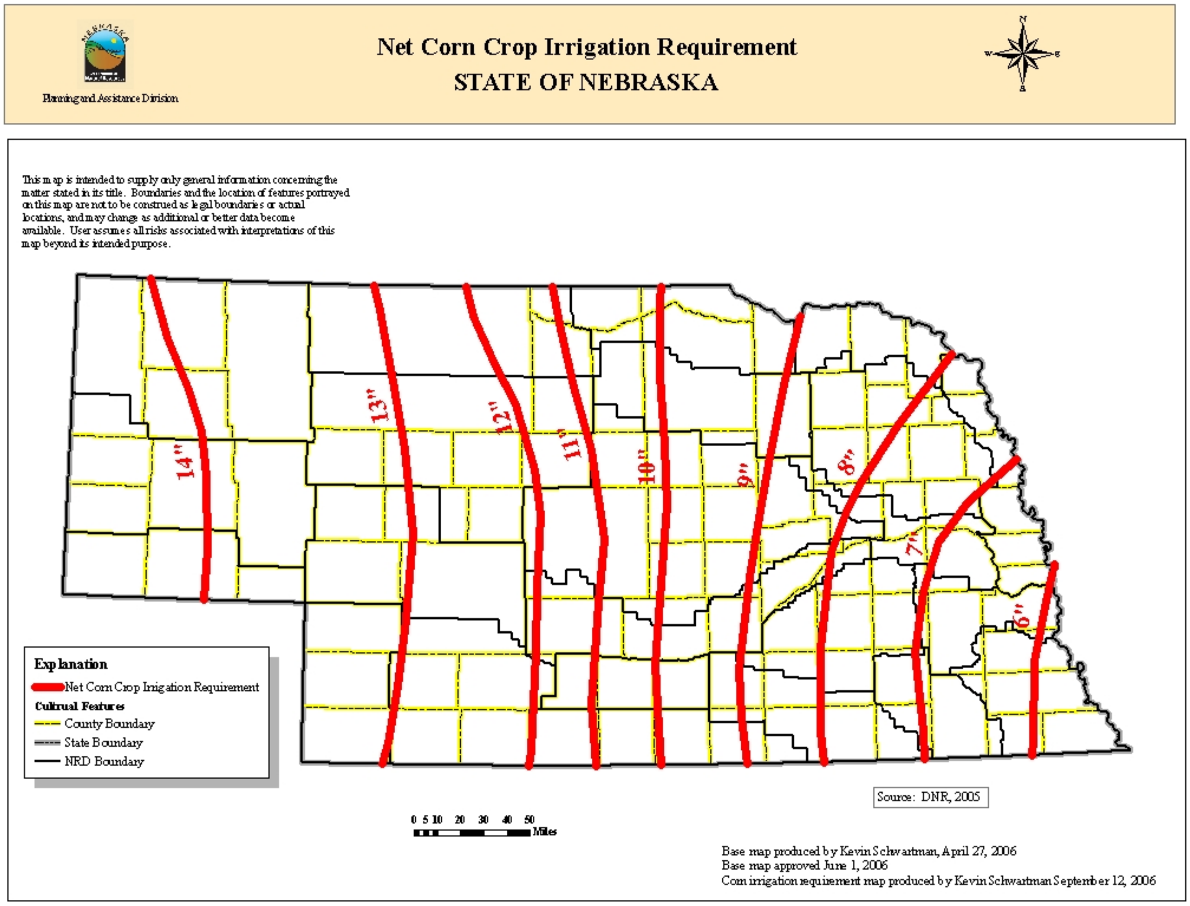
Step 1: Determine the Level of Surface Water Administration in the Past Twenty Years

The level of surface water administration is determined based on Department records for calls for administration for the previous twenty years (1988-2007). The calls for administration are used to develop a twenty-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 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 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 (see Section 4.1.2). 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 4-4). The NCCIR distribution for each basin is set out in individual basin subsections. The method of developing the NCCIR is described in Appendix F.

Figure 4-4 Net corn crop irrigation requirement.



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 profitable corn crop using these assumptions: 1) a downtime of 10%, due to mechanical failures and other causes; 2) a diversion rate of 1 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%. 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 operator.

2) Interpolate between the NCCIR contours to determine the specific need of the operator.

3) Multiply the NCCIR by 0.65 and 0.85 to find the 65% and 85% 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 against the results of Step 1 (the average number of days over the previous twenty-year period (1988-2007) 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% or 85% 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 4.4. If the basin satisfies this test, then the second criterion is evaluated: the addition of lag impacts from current development.

4.4.3 Evaluation of Long Term Water Supplies

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 twenty-year period of streamflows (1988-2007) and the lag impacts from current levels of well development. In those basins for which the appropriate geologic and hydrologic data were available and no numerical models exist; the following steps were taken to compute the lag impact from current development:

1. Define the ground water boundary for the study area.
2. Extract all high capacity wells from the Department's database with a completion date prior to December 31, 2007.
3. Account for current year's development.
4. Estimate the volume of water pumped from each well.
5. Calculate the twenty-five-year lag impacts.
6. Create lag-adjusted flow record.
7. Determine number of diversion days available.

In those basins for which an appropriate numerical model exists (e.g., the Loup River Basin and portions of the Elkhorn River Basin), the lag impacts were calculated using the numerical model. In those basins for which the appropriate geologic and hydrologic data were not available, the lag impacts 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 net corn crop irrigation requirement, and the final conclusion would likely not change even with the addition of lag impacts.

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 ground water boundary is defined by certain features that include the location of perennial baseflow streams, location of non-hydrologically connected areas, and ground water table highs that prevent flow to the stream of interest.

An individual well may fall into multiple basin study areas. If a well falls within multiple basin study areas, its total stream depletion is divided by the number of basin study areas that it intersects. For example, if a well falls into two basin study areas, the depletion is divided by 2. This prevents overestimation of depletions in overlapping areas. A sufficient number of wells in an overlapping area will likely, on average, be halfway between the two basins. Because SDF methodology is distance-based, splitting the depletion in half and assigning half of the total depletion to each basin is justified.

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 fifty gallons per minute (gpm). High capacity wells include active irrigation, industrial, public water supply, and unprotected public water supply wells (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, 2007, were used in the analysis.

Step 3: Account for Current Year (2008) 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, 2008, and

December 31, 2008. The first step in estimating the number of high capacity wells for 2008 is to average the well development rates within a basin over the previous three-year period (2005-2007), taking into account known limitations, such as moratoriums, on well development. 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 land 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 forty 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, 2007, and those estimated to be developed in each basin for 2008 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 4.4.2) by the number of acres irrigated by the well. The number of acres irrigated by each well was estimated to be ninety acres, for reasons documented in Appendix G (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 4-4): 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 Twenty-Five-Year Lag Impacts

The Jenkins SDF methodology is utilized to estimate the twenty-five-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

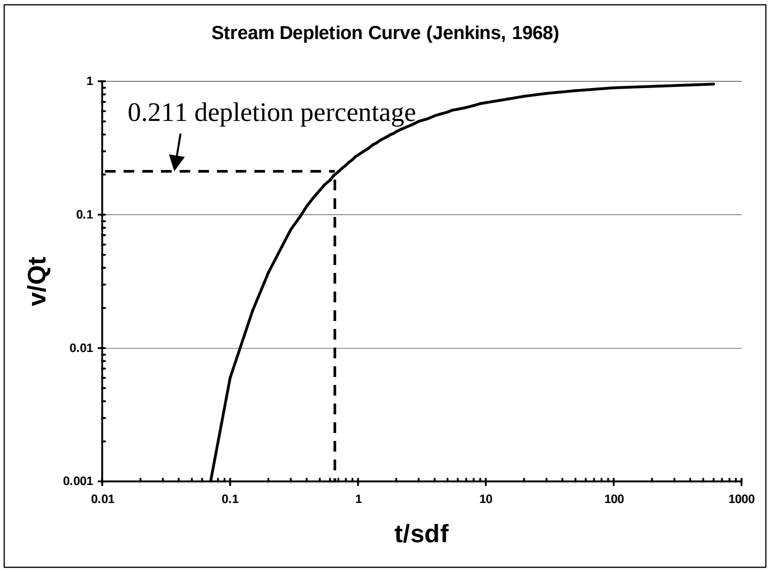
Dimensionless term: $\frac{tT}{a^2S}$ or $\frac{t}{sdf}$

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

- t is the time since the well was completed (2008-well completion year).
- 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% (see Figure 4-5).

Figure 4-5 Determining depletion percentage from the dimensionless term.



Finally, the stream depletion is calculated as follows:

v = Qt * percentage depletion

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 4-5

The depletion percentage is multiplied by the volume pumped, as calculated in Step Four, 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 twenty-five-year lag impacts. The twenty-five-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 twenty-five years (9,125 days). The depletion rate calculated in 2008 is subtracted from the depletion rate calculated in 2033 (twenty-five 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 twenty-five-year lag impacts.

<table>
<tr><th>Year</th><th>Cumulative Depletion
(cfs)</th><th>Additional Annual
Depletion
(cfs)</th><th>Lag
(cfs)</th></tr>
<tr><td>2007</td><td>100</td><td rowspan="2">10</td><td rowspan="4">20</td></tr>
<tr><td>2008</td><td>110</td></tr>
<tr><td>2032</td><td>300</td><td rowspan="2">30</td></tr>
<tr><td>2033</td><td>330</td></tr>
</table>

Step 6: Create Lag-Adjusted Flow Record

The twenty-five-year lag impacts from all current wells within a basin are summed to generate a total stream depletion figure for the basin. A daily historic flow record is developed from stream gage data for the previous twenty-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 calculate the average number of days available to the most junior appropriator within the basin for diversion. 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% or 85% criterion is less than the average number of days available for diversion, then the basin, subbasin, or reach may be declared fully appropriated.

4.4.4 Peer Review of the Methodology

The methodology developed by the Department and described in Sections 4.4.2 and 4.4.3 was independently peer reviewed by the Nebraska Water Science Center of the U.S. Geological Survey in October 2005. The Center concluded, “The NWSC reviewers found the document technically sound.” A copy of the peer review transmittal letter is in Appendix D.

4.4.5 Determining Erosion of Rights

If a basin has failed either the first or second criterion (described in Sections 4.4.2 and 4.4.3), then the next step in the Department’s analysis is to apply what has been termed “the erosion rule” (457 N.A.C. 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 the 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.

In the event that the junior water right is not an irrigation right, regulation 457 N.A.C. 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 through the use of 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 twenty-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 previous twenty years (i.e., 1988-2007). 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 twenty-year period prior to the appropriation being granted.
2. Gather the daily streamflow records for 1988-2007 to serve as the current twenty-year period.
3. Determine the twenty-five-year lagged ground water depletions from wells existing on the date the junior surface water appropriation was granted, and subtract them from the daily streamflow record for the twenty-year period prior to the granting of the appropriation.
4. Determine the twenty-five-year lagged ground water depletions from wells existing at the end of the current twenty-year period (using methodologies described in Section 4.4.4), and subtract them from the daily streamflow record for the current twenty-year period (1988-2007).
5. Assume that surface water administration would occur if the flow requirement of a senior surface water appropriation was greater than the depleted historical daily flow.
6. Conduct a month-by-month comparison of the average number of days available for the junior surface water appropriation to divert during the twenty-year period prior to the appropriation and the average number of days available to divert during the current twenty-year period.

If the average number of days available to the junior surface water appropriation for diversion during the current period (1988-2007) is less than the number of days available to the junior surface water appropriation for the twenty-year period prior to the appropriation, then the appropriation may be determined to be eroded.

4.4.6 Evaluation of Compliance with State and Federal Laws

To evaluate compliance with state and federal law, it was determined that, currently, only the state and federal laws prohibiting the taking of threatened and endangered species could raise compliance issues under section 46-713(3)(c). The federal Endangered Species Act, 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) and by degrading or destroying a species' habitat so much that the species cannot survive (50 CFR § 17.3). The state Nongame and Endangered Species Conservation Act, Neb. Rev. Stat. §§ 37-801 *et seq.*, also prohibits the actual killing or harming of an individual member of a listed species, but it is not clear whether the degradation of a species' habitat is considered a taking under state law. For this year's report it was concluded that a reduction in streamflow will not cause noncompliance with either the federal or state endangered species laws in any of the basins evaluated at this time.

4.4.7 Evaluating Predicted Future Development in a Basin

The Department is required by section 46-713 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. The analysis does, however, 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 4.4.3. The specific steps necessary to conduct an analysis of the impacts of future well development on the status of a basin are as follows:

- Gather information on lag impacts of current wells (from calculations performed in Section 4.4.3).
- Project the rate of future well development.
- Incorporate projected future well development into the study area.
- Calculate the depletions of projected future well development.
- Subtract the depletions of projected future well development from the previous twenty-year lag-adjusted flow record (1988-2007), 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 4.4.3 above, and the lag-adjusted flow record developed in Step 7 of Section 4.4.3 is that discussed in this section. In using the lag-adjusted flow record, the twenty-five-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 ten years (1998-2007). 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 land 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 forty 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 4.4.3. The depletions of future wells are calculated independently of current well development. The twenty-five-year depletions from future well development are removed from the lag-adjusted flow record created in Step 7 of Section 4.4.3 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 twenty-five-year lag impacts from all current wells created at the end of Step 5 in Section 4.4.3 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 twenty-five-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 period 1988-2007 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.

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