

Monitoring & Studies Technical Memorandum for the URNRD, MRNRD, and LRNRD IMPs

Jointly developed by:
The Nebraska Department of Natural Resources (NeDNR),
The Upper Republican Natural Resources District (URNRD),
The Middle Republican Natural Resources District (MRNRD),
and
The Lower Republican Natural Resources District (LRNRD)

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I. Purpose and Revisions

This memorandum was originally developed and adopted concurrently with the fifth generation Integrated Management Plans (IMPs) jointly developed by NeDNR and each of the three Natural Resources Districts (NRDs), as indicated in each of the three IMPs (referred to cumulatively as “the IMPs”). It contains the specific calculations and other procedures to fulfill the requirements

of the monitoring plans in the IMPs. This memorandum should not be used in isolation; it is intended to be used together with the procedures, requirements, and definitions specified in the IMPs. For definitions of terms used throughout this document, refer to the "Definitions" section of the IMPs.

This memorandum, and the procedures contained herein, may only be revised following the technical memorandum revision process described in the "Monitoring and Studies" section of the IMPs. Once adopted, each new version of this memorandum will supersede all previous versions, as of the new memorandum's effective date.

II. Forecast and Compact Call Year Evaluation Procedures

The following sections describe the procedures used for the short-term and long-term forecasts and to determine whether a Compact Call Year is required. Prior to January 1 of each year, in compliance with *Neb. Rev. Stat. § 46-715(6)*, the NeDNR, in consultation with the Republican Basin NRDs, shall forecast the maximum amount of water that may be available from streamflow for beneficial use in the short term and long term to comply with the Republican River Compact (Compact). In addition, to assist NeDNR and the NRDs with ensuring compliance with the Compact, NeDNR, in conjunction with the NRDs, shall forecast Nebraska's available water supplies, beneficial consumptive use, and Compact accounting balances and shall evaluate these forecasted values and other available information. If this evaluation indicates that additional management actions might be necessary in the coming year for Compact compliance, a Compact Call Year will be designated.

A. Short-Term Forecast

The short-term forecast will project the next year's one-year balances (projected Nebraska allocation plus projected Imported Water Supply less the projected Computed Beneficial Consumptive Use, or CBCU) at Guide Rock and Hardy, as well as the projected Guide Rock (RRCA Accounting Procedures Table 5C) and Hardy (RRCA Accounting Procedures Table 3C) accounting balances over the appropriate averaging periods.

These balances will be used in conjunction with other information to determine whether a Compact Call Year is required for the next year. NeDNR and the NRDs will review the forecasted values and other available information and determine whether additional management actions must be implemented within any NRD for Compact compliance ("Compact Call Year Evaluation," page 6).

1. RRCA Accounting Tests and Forecast Values

Nebraska's Compact compliance is evaluated at two locations: Guide Rock and Hardy. Nebraska's Compact compliance tests use five-year averaging upstream of

Hardy in every year and may also include an additional test based on two-year averaging upstream of Guide Rock or an alternative accounting of three-year averaging upstream of Guide Rock, based on the irrigation supply in Harlan County Lake.

Forecast values are calculated for both Guide Rock and Hardy compliance tests. The NeDNR's forecast values for Guide Rock will include:

- The one-year balance,
- The two-year average balance, and
- The three-year average balance, when applicable.*

Forecast values for Hardy will include:

- The one-year balance and
- The five-year average balance.

2. Terms and Information Used

Table 1 defines the terms and subscripts used throughout the equations for the short-term forecast. Data used for previous years will be approved or provisional RRCA accounting values. Data used for the current year will be estimated from preliminary data, groundwater modeling estimates, and previous years' values.

* Three-year averaging is applicable if it is beneficial to use the Alternative Water-Short Year Plan provisions from the Final Settlement Stipulation (i.e., if the previous two years have a greater balance than the last year alone) and an Alternative Water-Short Year Plan has been approved by the RRCA.

Table 1. Abbreviations used for the short-term forecast procedures.

Abbreviation	Definition
T = 0	The current year (the year in which the forecast is being calculated)
T - 1, T - 2, T - 3	1, 2, and 3 years before the current year
T + 1	The upcoming year that is being forecast
Hardy, Guide Rock, Below Guide Rock	Subscripts used on other terms to indicate the area in Nebraska to which the term pertains: the basin upstream of Hardy, the basin upstream of Guide Rock, or downstream of Guide Rock, respectively
CO, KS	Subscripts used on other terms to indicate that the term pertains to the state of Colorado or Kansas, respectively
CWS	Nebraska's Computed Water Supply
IWS	Nebraska's Imported Water Supply credit
CBCU	Nebraska's total Computed Beneficial Consumptive Use
GwCBCU	Groundwater Computed Beneficial Consumptive Use
SwCBCU	Surface Water Computed Beneficial Consumptive Use
Nebraska Allocation	The amount of water the State of Nebraska is allowed to use in year T + 1
Balance	The sum of Nebraska's Allocation and the Nebraska Imported Water Supply, less Nebraska's Computed Beneficial Consumptive Use
HCL Content	Harlan County Lake content as of January 1 of year T + 1
NE Lake Volume	Nebraska Lake content for the five US Bureau of Reclamation Reservoirs as of January 1 of year T + 1, or estimated based on alternative surface water project sponsor plans
af	Acre-feet

3. Projected Hardy One-Year Balance

The following equations are used to determine Nebraska's one-year Hardy balances for the forecast year. All terms are for the forecast year (T + 1) unless otherwise specified.

$$\text{Hardy One-Year Balance} = \text{Allocation}_{\text{Hardy}} + \text{IWS} - \text{CBCU}_{\text{Hardy}}$$

Where:

$$\text{Nebraska Allocation}_{\text{Hardy}} = \text{CWS}_{\text{Hardy}} * 0.5$$

$$\begin{aligned} \text{CWS}_{\text{Hardy}} = & \text{SwCBCU}_{\text{Hardy}} + \text{SwCBCU}_{\text{KS}} + \text{SwCBCU}_{\text{CO}} \\ & + \text{GwCBCU}_{\text{Hardy}} + \text{GwCBCU}_{\text{KS}} + \text{GwCBCU}_{\text{CO}} \\ & + \text{Stateline Streamflow} \end{aligned}$$

$$\text{IWS} = \text{Two-year average of T = 0 and T - 1 IWS values}$$

$$\text{CBCU}_{\text{Hardy}} = \text{SwCBCU}_{\text{Hardy}} + \text{GwCBCU}_{\text{Hardy}}$$

$$\text{SwCBCU}_{\text{Hardy}} = -4 \times 10^{-7} * (\text{NE lake volume})^2 + 0.52 * (\text{NE lake volume}) - 42,000 \text{ af}$$

$$\text{SwCBCU}_{\text{KS}} = 0.1858 * \text{HCL content} + 9,575 \text{ af}$$

$SwCBCU_{CO} = \text{Two-year average of } T - 1 \text{ and } T - 2 SwCBCU_{CO}$

$GwCBCU_{Hardy}$, $GwCBCU_{KS}$, $GwCBCU_{CO} = \text{Two-year average of } T = 0 \text{ and } T - 1$
 $GwCBCU$ values for Nebraska (Hardy), Kansas, and Colorado, respectively;
 or $GwCBCU_{Hardy}$ may be based on alternative information provided by
 NRDs[†]

$\text{Stateline Streamflow} = 0.41 * (\text{5-year average of previous years' Stateline Streamflow}) + 0.23 * \text{HCL content} - 27,450 \text{ af}$

4. Projected Guide Rock One-Year Balance

The following equations are used to determine Nebraska's one-year balance upstream of Guide Rock for the forecast year. The forecast values for Guide Rock are back-calculated from the forecasted Hardy values based on the empirical relationship between the two balance. All terms are for the forecast year ($T + 1$) unless otherwise specified.

Guide Rock One-Year Balance = Hardy One-Year Balance * 0.89 – 9040 af

$\text{Allocation}_{\text{Guide Rock}} = \text{Guide Rock One-Year Balance} - \text{IWS} + \text{CBCU}_{\text{Guide Rock}}$

$\text{CBCU}_{\text{Guide Rock}} = \text{SwCBCU}_{\text{Guide Rock}} + \text{GwCBCU}_{\text{Guide Rock}}$

$\text{SwCBCU}_{\text{Guide Rock}} = \text{SwCBCU}_{\text{Hardy}} - \text{Two-year average of } T = 0 \text{ and } T - 1$
 $\text{SwCBCU}_{\text{Below Guide Rock values}}$

$\text{GwCBCU}_{\text{Guide Rock}} = \text{Two-year average of } T = 0 \text{ and } T - 1 \text{ GwCBCU}_{\text{Guide Rock values}}$

5. Projected Two, Three, and Five-Year Average Balances

Nebraska's one-year balance for Hardy (year $T + 1$) will be averaged with the previous four years' approved or preliminary RRCA accounting balances to project the five-year average upstream of Hardy. Nebraska's one-year balance for Guide Rock (year $T + 1$) will be averaged with the applicable previous years' approved or preliminary RRCA accounting balances to project the two-year or three-year average upstream of Guide Rock.

[†] If management actions are expected to limit groundwater pumping within an NRD to be less than the previous two-year average, a revised estimate of $GwCBCU$ for Nebraska may be developed. Prior to NeDNR incorporating these management actions into any updates, the NRD will provide the maximum groundwater pumping allocation and a map indicating the geographic area where the allocation or other management actions apply. NeDNR will use such information provided by the NRD and represent such information in the RRCA groundwater model. These updated $GwCBCU$ values will be used in the forecast and also for estimating each NRD's balance before pumping data are available.

B. Compact Call Year Evaluation

This section details the procedures that will be used to determine whether the upcoming year is a Compact Call Year. The Compact Call Year decision consists of two evaluations: one evaluation for Hardy and one for Guide Rock. Both evaluations must be completed each year, as shown in Figure 1.

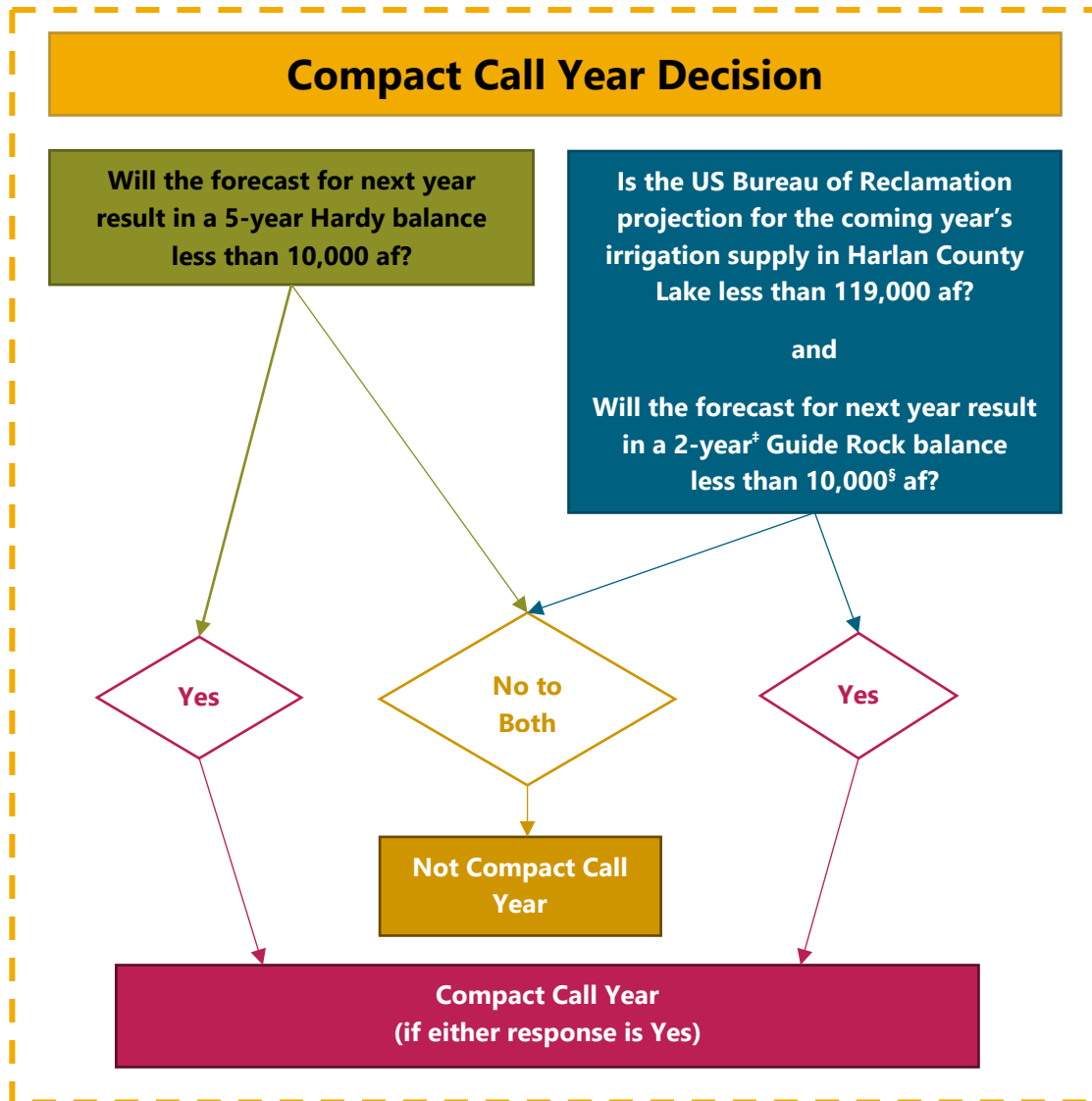


Figure 1. The Compact Call Year decision framework for the Republican River Basin consists of two tests, as illustrated in this figure.^{‡,§}

[‡] If it is beneficial to use the Alternative Water-Short Year Plan provisions from the Final Settlement Stipulation (i.e., if the previous two years have a greater balance than the last year alone), and if an Alternative Water-Short Year Plan has been approved by the RRCA, then substitute “3-year” for “2-year” in the Guide Rock test.

[§] In the second consecutive Compact Call Year, the 10,000 af threshold for the Guide Rock test will be reduced to 5,000 af. For the third and subsequent consecutive Compact Call Years, this value will be reduced to zero.

C. Long-Term Forecast

Due to the absence of a long-term trend in water supplies, the periods of low water supplies in the future are likely to be similar to periods of low water supplies from the past. Historically, the minimum water supplies that have been available to Nebraska were approximately 200,000 acre-feet. Therefore, the amount of water that may be available from streamflow for beneficial use ten years in the future, assuming several consecutive dry years, is estimated to be approximately 200,000 acre-feet. NeDNR will continue to estimate minimum water supplies and long-term trends to monitor whether future changes are needed to these long-term forecast procedures.

III. Compact Compliance Actions

As described in the IMPs, NeDNR will estimate each NRD's share of Nebraska's Republican River Compact (Compact) obligations before January 1 of each Compact Call Year and will provide the NRDs with updated estimates as needed throughout the year. This section includes the formulas and procedures used to estimate the volume of water each NRD may need to provide through management actions to make up remaining deficits during the year for Compact compliance. This section provides instructions for evaluating each NRD's balances and its management action requirements to ensure compliance with the Compact by keeping its Net Groundwater Depletions to streamflow within its share of Nebraska's available water supplies under the Compact.

A. RRCA Accounting and Applicable Averaging Periods

Nebraska's Compact compliance tests use five-year averaging upstream of Hardy every year and may also include an additional test based on two-year averaging upstream of Guide Rock or an alternative accounting of three-year averaging upstream of Guide Rock. The methods of determining applicable accounting and averaging periods are specified in the Final Settlement Stipulation, Republican River Compact Administration (RRCA) Accounting Procedures, and RRCA resolutions and are not repeated here. The averaging periods, compliance points, and baseline depletion percentages used to evaluate compliance with the IMPs and the basin-wide plan will correspond with the applicable accounting for the RRCA for the same year.

B. Yield from Management Actions and Crediting

When an NRD implements programs or takes management actions to improve Nebraska's Compact balance, that improvement will be reflected in the NRDs' own balance. This includes improvement resulting from groundwater regulations and controls, surface water leases or agreements, augmentation, incentive programs, or other

management actions. Calculation of the water savings associated with management actions will be completed in conformance with RRCA Accounting Procedures.

Water savings resulting from groundwater regulations or other programs resulting in reduced groundwater pumping are represented in the RRCA groundwater model, resulting in a lower groundwater CBCU for the NRD. Therefore, the benefits to the NRD of regulations or programs to reduce groundwater pumping are included in the equations below as part of the term “_RNRD GwCBCU.”

In contrast, many of the other kinds of programs and management actions listed above do not affect groundwater pumping, thus their benefits are not represented in the groundwater model. For programs and management actions not already represented in the groundwater model, a separate credit is given. When the IMPs or this memorandum refer to credit for water savings or yield from management actions, these terms are specifically referring to improvements in Nebraska’s Compact balance resulting from programs or management actions not already accounted for as a reduction to groundwater CBCU. Credits for management actions not already accounted for as part of groundwater CBCU are included in the equations below in the terms “All NRD Management Actions” and “_RNRD Management Actions.”

In addition to the credits described above for NRD management actions, current RRCA procedures include additional credits and future obligations for Nebraska, which are then distributed among the NRDs as follows. Under current RRCA procedures, when Nebraska’s balance is negative, management actions may be required within the year; alternatively, a different timeframe and conditions in which Nebraska will supply yield from management actions may be established than would have otherwise been required within the year.** When these alternative conditions apply, Nebraska’s credit and future obligation for deferred yield from management actions will be distributed proportionally to the NRDs with negative balances with the best available data at the time.

C. Determining each NRD’s Balance and Management Action Requirements

This section describes how the NRDs’ balances are to be calculated. It begins with the determination of the portion of Nebraska’s water supply under the Compact that is allotted to each NRD (“Allowable Groundwater Depletions,” below). Next, it specifies how this, and additional, information is used to determine the NRD’s annual and accounting period balances (“NRD Balances,” page 10). That subsection also describes the

** Current Compact compliance requirements allow for Nebraska to end an accounting year with a negative balance and for Kansas to retain this accounting balance for use in a subsequent Compact Call Year (Defined as: Remaining Compact Compliance Volume, Resolution Approving Long-Term Agreements Related to the Operation of Harlan County Lake for Compact Call Years, August 24, 2016).

relationship between NRD balances, the IMPs' short-term compliance standard, and MHO A from the basin-wide plan. Finally, this section concludes by describing how each NRD's management actions necessary to ensure Compact compliance are determined ("Establishing Management Action Requirements," page 11). In the equations in this section, "_RNRD" represents an individual NRD (URNRD, MRNRD, or LRNRD).

1. Allowable Groundwater Depletions

"Allowable Groundwater Depletions for Nebraska" refers to the depletions to streamflow from groundwater pumping within URNRD, MRNRD, and LRNRD, cumulatively, that can be allowed in any one year without exceeding the Compact allocation. Under the IMPs, each NRD is allotted a fixed proportion of the Allowable Groundwater Depletions for Nebraska, based on the agreed-upon Baseline Depletion Percentages.^{††} The equations below show how Allowable Groundwater Depletions for each NRD are calculated.

The data used in these calculations are to be consistent with RRCA Accounting Procedures and RRCA accounting data and use best-available information NeDNR has at the time of the calculation. These same equations are used for both the basin upstream of Hardy (five-year accounting) and the basin upstream of Guide Rock (two or three-year accounting).

$$\text{Allowable Groundwater Depletions for Nebraska} = \text{Nebraska Allocation} + \text{Nebraska Credits} - \text{SwCBCU}_{\text{NE}} - \text{Other NRD CBCU}$$

Where:

Nebraska Allocation = Nebraska's water supply under the Compact;

Nebraska Credits = Nebraska's Imported Water Supply credit (IWS) and Nebraska Resolution Water Supply credit (NERWS);

SwCBCU_{NE} = the surface water consumptive use by Nebraska, including net evaporative losses; and

Other NRD CBCU = the groundwater CBCU calculated for the South Platte NRD, Twin Platte NRD, Tri-Basin NRD, Central Platte NRD, and Little Blue NRDs.

$$\text{_RNRD Allocation} = (\text{Allowable Groundwater Depletions for Nebraska} - \text{All NRD Management Actions}) * \text{Applicable Baseline Depletion Percentage}$$

^{††} The Baseline Depletion Percentages assigned to the NRDs for the basin upstream of Hardy are: URNRD, 43.9 %; MRNRD, 30.8 %; and LRNRD, 25.3 %. The Baseline Depletion Percentages assigned to the NRDs for the basin upstream of Guide Rock are URNRD, 44.4 %; MRNRD, 31.1 %; and LRNRD, 24.5 %.

Where:

Allowable Groundwater Depletions for Nebraska is calculated as shown in the previous equation;

All NRD Management Actions = the total yield of all management actions taken by URNRD, MRNRD, and LRNRD that are not represented in the RRCA groundwater model (set to zero at the time of the forecast, projected values for preliminary accounting estimates, and final reported values for final accounting)

Applicable Baseline Depletion Percentage = the Baseline Depletion Percentage for _RNRD for the applicable averaging period.††

**Allowable Groundwater Depletions for _RNRD =
_RNRD Allocation + Applicable Previous Years' Balance**

Where:

_RNRD Allocation is calculated as shown in the previous equation; and

Applicable Previous Years' Annual Balance = the _RNRD's annual balance from previous years within the appropriate averaging period.

2. NRD Balances

The calculation to determine each NRD's annual and averaging period balances shall be performed with preliminary, projected, or finalized data, as available, Compact accounting values applicable to the current year, as follows:

**_RNRD Annual Balance =
_RNRD Allocation – _RNRD GwCBCU + _RNRD Management Actions**

Where:

_RNRD Allocation is calculated as shown in the previous equation;

_RNRD GwCBCU = the portion of Nebraska's groundwater CBCU that is attributable to _RNRD based on the most recent NeDNR groundwater model update; and

_RNRD Management Actions = the yield from _RNRD's management actions that are not represented in the RRCA groundwater model (set to zero at the time of the forecast, projected values for preliminary accounting, and final reported values for final accounting)

_RNRD Averaging Period Balance = the average of the NRD's Annual Balances over the appropriate averaging period

Note that the IMPs' short-term compliance standard (Compliance Standard ii.) and MHO A from the basin-wide plan both ask whether each NRD's net depletions to streamflow are within its Allowable Groundwater Depletions. Because the NRD's net depletions to streamflow equal the NRD's GwCBCU plus its yield from management actions, and the term "Allowable Groundwater Depletions for _RNRD" includes the NRD's Allocation plus applicable previous years' balances, both MHO A and the IMP's short-term compliance standard are mathematically equivalent to assessing whether the NRD's final Averaging Period Balance is positive. If an NRD's final Averaging Period Balance is positive for the year being assessed, that NRD has met both the short-term compliance standard and MHO A for that year. If an NRD's final Averaging Period Balance is negative for the year being assessed, management actions are required, as described in the "Compliance Standards" section of the IMPs.

3. Establishing Management Action Requirements

NeDNR will establish each NRD's projected Averaging Period Balance before January 1 of each Compact Call Year and as needed throughout the Compact Call Year as follows. Each evaluation will specify the NRD's balances, whether additional management actions are necessary, and the timeframe within which the management actions need to be performed. The results of each evaluation will be rounded to the nearest 100 acre-feet.

If an NRD's Averaging Period Balance is positive and that NRD has no previous year obligations at the time of the evaluation, no further management actions will be necessary by that NRD at that time. If an NRD's Averaging Period Balance is negative, then that NRD's portion of Nebraska's total required yield from management actions will be proportional to that NRD's negative Averaging Period Balance relative to the sum of all other negative NRD balances. This negative balance will be added to any Remaining Compact Compliance Volume that was previously assigned to an NRD.

The required yield of NRD management actions and duration of NeDNR water administration (described in the IMPs' controls) will be reevaluated throughout the year in the context of changes in expected water supplies and water uses, the NRD management actions that have been or may be implemented, approved RRCA modifications, or other administrative, operational, and hydrologic factors. After an NRD provides notification of planned management actions, NeDNR will calculate the yield and crediting from the management actions as described in Section B and use the yield from these planned management actions to update a balance for that NRD as described in Section C.

Note that this section is limited to describing the determination of management actions necessary to ensure compliance with the Compact. The IMPs also include

other potential management action triggers not addressed in this technical document, as described under "IMP and Basin-Wide Plan Compliance" in the IMPs.