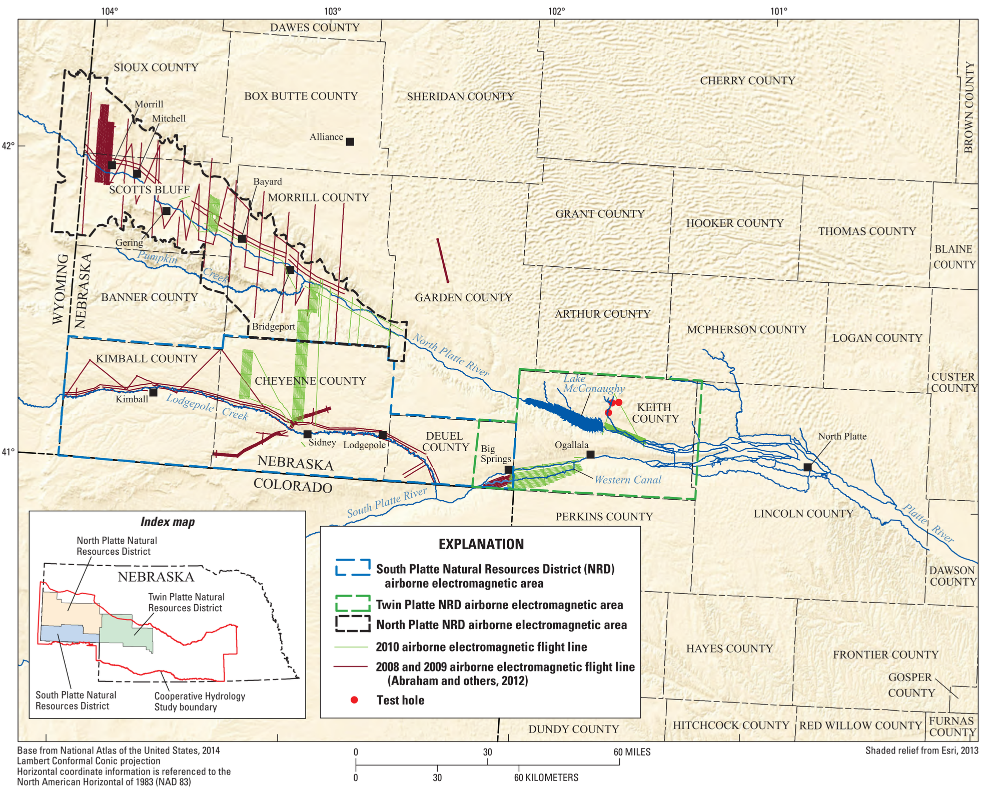

Figure 1. Location of 2010 airborne electromagnetic (AEM) flight lines (this study), and 2008 and 2009 airborne electromagnetic flight lines.

ABSTRACT

Water resources in the North and South Platte River valleys of Nebraska, including the valley of Lodgepole Creek, are critical to the social and economic health of the area, and for the recovery of threatened and endangered species in the Platte River Basin. Groundwater and surface water are heavily used resources, and uses are regulated in the study area. Irrigation is the dominant water use and, in most instances, is supplied by both groundwater and surface-water sources. The U.S. Geological Survey and its partners have collaborated to use airborne geophysical surveys for areas of the North and South Platte River valleys including the valley of Lodgepole Creek in western Nebraska. The objective of the surveys was to map the aquifers and underlying bedrock topography of selected areas to help improve the understanding of groundwater–surface-water relations to guide water-management decisions. This project was a cooperative study involving the North Platte Natural Resources District, the South Platte Natural Resources District, the Twin Platte Natural Resources District, the Conservation and Survey Division of the University of Nebraska-Lincoln, and the Nebraska Environmental Trust.

This report presents the interpreted base-of-aquifer surface for part of the area consisting of the North Platte Natural Resources District, the South Platte Natural Resources District, and the Twin Platte Natural Resources District. The interpretations presented herein build on work done by previous researchers from 2008 to 2009 by incorporating additional airborne electromagnetic survey data collected in 2010 and additional test holes from separate, related studies. To make the airborne electromagnetic data useful, numerical inversion was used to convert the measured data into a depth-dependent subsurface resistivity model. An interpretation of the elevation and configuration of the base of aquifer was completed in a geographic information system that provided *x, y*, and *z* coordinates. The process of interpretation involved manually picking locations (base-of-aquifer elevations) on the displayed airborne electromagnetic-derived resistivity profile by the project geophysicist, hydrologist, and geologist. These locations, or picks, of the base-of-aquifer elevation (typically the top of the Brule Formation of the White River Group) were then stored in a georeferenced database. The pick was made by comparing the inverted airborne electromagnetic-derived resistivity profile to the lithologic descriptions and borehole geophysical logs from nearby test holes. The database of interpretive picks of the base-of-aquifer elevation was used to create primary input for interpolating the new base-of-aquifer contours.

The automatically generated contours were manually adjusted based on the interpreted location of paleovalleys eroded into the base-of-aquifer surface and associated bedrock highs, many of which were unmapped before this study. When contours are overlain by the water-table surface, the saturated thickness of the aquifer can be computed, which allows an estimate of total water in storage. The contours of the base-of-aquifer surface presented in this report may be used as the lower boundary layer in existing and future groundwater-flow models. The integration of geophysical data into the contouring process facilitated a more continuous and spatially comprehensive view of the hydrogeologic framework.

INTRODUCTION

Water resources in the North and South Platte River valleys of Nebraska, including the valley of Lodgepole Creek (fig. 1), are critical to the social and economic health of the area, and the management of endangered species along the Platte River corridor. Both groundwater and surface water are heavily used resources, and uses are regulated in the study area and in the entire Platte River Basin. In addition to regulated water resources use is the need to provide water for the recovery of threatened and endangered species in the Platte River Basin. The Platte River Recovery and Implementation Program (PRRIP) is a partnership between the U.S. Department of the Interior, and the States of Wyoming, Colorado, and Nebraska to manage habitat and water for recovery of the threatened and endangered species in the Big Bend reach (not shown in any maps) of the Platte River (Kenny, 2008). Water for the program is stored in Lake McConaughy or received from the South Platte River (fig. 1). Some of the water from the North Platte River is distributed downstream to the Big Bend reach of the Platte River to improve and maintain the habitat of threatened or endangered species (Kenny, 2008). Before reaching Lake McConaughy (fig. 1), the lowest reservoir on the North Platte River, snowmelt runoff from its mountain headwaters passes through many reservoirs, canal systems, and tributaries, and provides a large percentage of the recharge to the aquifers within the valley alluvium. The complexities of the interaction of the groundwater and surface-water systems are similar in the South Platte River Basin. Understanding the complex groundwater and surface-water interactions of the North and South Platte Rivers, and Lodgepole Creek (fig. 1), allows managers to better regulate the limited supplies of water for all uses including environmental flows required for endangered species.

Primary groundwater and surface-water management concerns include those related to water availability and water quality for human uses, and these concerns exist both locally and downstream from the study area. Irrigation is the dominant water use, which in most instances is supplied by both groundwater and surface-water sources (Carney, 2008; Luckey and Cannia, 2006). The study area covers parts of western Nebraska, and typically receives between 33 and 48 centimeters (cm; 13 and 19 inches [in.], respectively) of precipitation annually (National Oceanic and Atmospheric Administration, 2014). Supplemental water through irrigation is necessary for agriculture. In the South Platte River and Lodgepole Creek drainage basins, dual sources (both groundwater and surface water) are used to irrigate approximately 54,000 hectares (ha; 133,000 acres) of crops (South Platte Natural Resources District, 2008). Much of the water provided for irrigation is used and reused multiple times along its course downstream. The use of dual-sources creates a complex interaction between its source and its fate, which can make water management challenging.

Because of the multiple water uses and the consequential management challenges, additional data regarding water resources are required for use in other studies, including the U.S. Geological Survey (USGS) High Plains "Groundwater Availability Study" (Houston and others, 2013; Qi, 2010; Qi and Christenson, 2010; Stanton and others, 2011) and the Cooperative Hydrology Study (COHYST; Carney, 2008; Peterson, 2007; Luckey and Cannia, 2006). Additionally, water-resources data are actively being incorporated within the "Simulation of Groundwater Flow and Analysis of the Effects of the Water Management Options in the North Platte Natural Resources District (NPNRD) Study," which will be referred to hereinafter as the NPNRD Groundwater Management Model (S.M. Peterson, U.S. Geological Survey, oral commun., 2011). Refinement of the base-of-aquifer (BOA) configuration will improve the reliability of the predictions made with these models. One approach to deriving and refining the BOA configuration is the use of airborne electromagnetic (AEM) surveys.

From 2008 to 2010, the USGS and its cooperators collaborated to use airborne geophysical surveys for areas of the North and South Platte River valleys including the valley of Lodgepole Creek in western Nebraska (fig. 1). The objective of the surveys was to map the aquifers and underlying bedrock topography of selected areas to help improve the understanding of groundwater and surface-water interactions to guide water-management decisions. This project was a cooperative study involving the Nebraska Environmental Trust, the NPNRD, the South Platte Natural Resources District (SPNRD), the Twin Platte Natural Resources District (TPNRD), Conservation and Survey Division of the University of Nebraska-Lincoln, and the USGS.

This report presents the interpreted BOA surface for parts of the area consisting of the NPNRD, SPNRD, and TPNRD (figs. 2 and 3). The interpretations presented in this report build on previous work (Abraham and others, 2012) by including AEM survey data collected in 2010 (U.S. Geological Survey Crustal Geophysics and Geochemistry Science Center, 2014), and lithologic descriptions and borehole geophysical logs from additional test holes provided by separate but related studies (James C. Cannia, U.S Geological Survey, written commun., 2012; Hobza and Sibray, 2014; T.A. Kuntz, Adaptive Resources Inc., written commun., 2012). This information will be used to improve the accuracy and representativeness of the existing hydrogeologic frameworks of the NPNRD, SPNRD, and TPNRD.

The geology and water resources in the study area have been described by many earlier investigators (Darton, 1903a, 1903b; Wenzel and others, 1946; Bjorklund, 1957; Smith, 1969; Smith and Souders, 1971, 1975; Swinehart and others, 1985; Souders, 1986; Sibray and Zhang, 1994; Steele and others, 2007). Cannia and others (2006) constructed a hydrostratigraphic framework and characterization of underlying aquifers of the COHYST area (fig. 1) that were used in recently published groundwater-flow models (Carney, 2008; Luckey and Cannia, 2006), which included all of the study area. Within the study area the principal aquifer is the High Plains aquifer system, which is composed of the following geologic units:

- Quaternary-age deposits of alluvium and valley-fill deposits, and eolian sand;
- Broadwater Formation of Tertiary age;
- Ogallala Group of Tertiary age;
- Arikaree Group of Tertiary age; and
- Brule Formation of the White River Group (referred to hereafter as the Brule) of Tertiary age, where the Brule is fractured (Gutentag and others, 1984; Cannia and others, 2006).

The Brule forms the BOA in most parts of the study area. Cannia and others (2006) mapped localized areas where the Brule is absent; undifferentiated Cretaceous-age units form the BOA near the North Platte River in the western part of the NPNRD and in the TPNRD south of Lake McConaughy (fig. 1).

METHODS

This section of the report summarizes the methods used to enhance existing BOA contours using information from additional AEM surveys. Further detail and information regarding the processing workflow including geophysical data processing and inversion can be located in Abraham and others (2012).

Hypsometric contours of the BOA surface of the study area were modified using the following data: lithologic descriptions and borehole geophysical logs from additional test holes, time-domain electromagnetic (TDEM) surveys, and AEM surveys. Investigation of the BOA began by first assembling all the available information, which included existing geographic information system (GIS) data for BOA contours (Abraham and others, 2012; Cannia and others, 2006), depth to the geologic units that form the BOA at available test holes (University of Nebraska-Lincoln, Conservation and Survey Division, 2014), test holes drilled in separate but related studies (J.C. Cannia, U.S. Geological Survey, written commun., 2012; Hobza and Sibray, 2014; T.A. Kuntz, Adaptive Resources Inc., written commun., 2012), and digitized unpublished hand-drawn outcrop maps (R.F. Diffendal Jr., University of Nebraska-Lincoln, Conservation and Survey Division, unpub. data, 2013; J.B. Swinehart, University of Nebraska-Lincoln, Conservation and Survey Division, unpub. data, 2013). The data supporting the BOA interpretations presented in this report include information from AEM surveys completed in 2010 using the SkyTEM system (U.S. Geological Survey Crustal Geophysics and Geochemistry Science Center, 2014). AEM surveys increasingly have been used to characterize aquifers and their geologic setting (Smith and others, 2007). The SkyTEM is a TDEM mapping platform that was used to map the electrical properties of earth materials from the near-surface 10 meters (m; 33 feet [ft]) down to depths of 300–400 m (984–1,312 ft; U.S. Geological Survey Crustal Geophysics and Geochemistry Science Center, 2014).

For the 2010 AEM surveys, approximately 1,890 linear kilometers (km; 1,174 miles [mi]) of data were collected (fig. 1). The AEM surveys for the selected areas were conducted using two distinct methods: block flights and reconnaissance lines. Block flights were characterized by tightly spaced lines, uniformly spaced 220–400 m (722–1,312 ft) apart, and trended in a uniform direction. An example of a block flight oriented in a north-south direction can be located northwest of Sidney in figure 1. The second configuration used widely spaced lines oriented in the direction likely to provide the widest areal coverage possible for identifying the BOA. These widely spaced lines were termed reconnaissance lines and provided an initial view of the subsurface in areas where the existing geologic framework was poorly constrained. An example of a reconnaissance line can be located as the single flight line trending north-south and beginning northeast of Sidney in figure 1. Within the NPNRD, 2010 AEM data collection included two block flights: one west of Bayard and another east of Bridgeport (fig. 1). Several reconnaissance lines also were collected parallel to the North Platte River, and several lines oriented north-south, east of Bridgeport (fig. 1). Within the SPNRD, two large block flights trending north-south were collected north of Lodgepole Creek: one in western Cheyenne County and one extending north from northwest of Sidney into the NPNRD was collected (fig. 1). Reconnaissance lines also were collected near the block flights (fig. 1). Within the TPNRD, AEM data collection included the following two block flights: one along Western Canal near the South Platte River, extending into Deuel County, and another along the North Platte River downstream from Lake McConaughy (fig. 1). Two reconnaissance lines were collected north of the block flight near Lake McConaughy (fig. 1). Three additional test holes were drilled in Keith County to provide additional ground truth for interpreting the reconnaissance lines (James Cannia, U.S. Geological Survey, written commun., 2012; fig. 1).

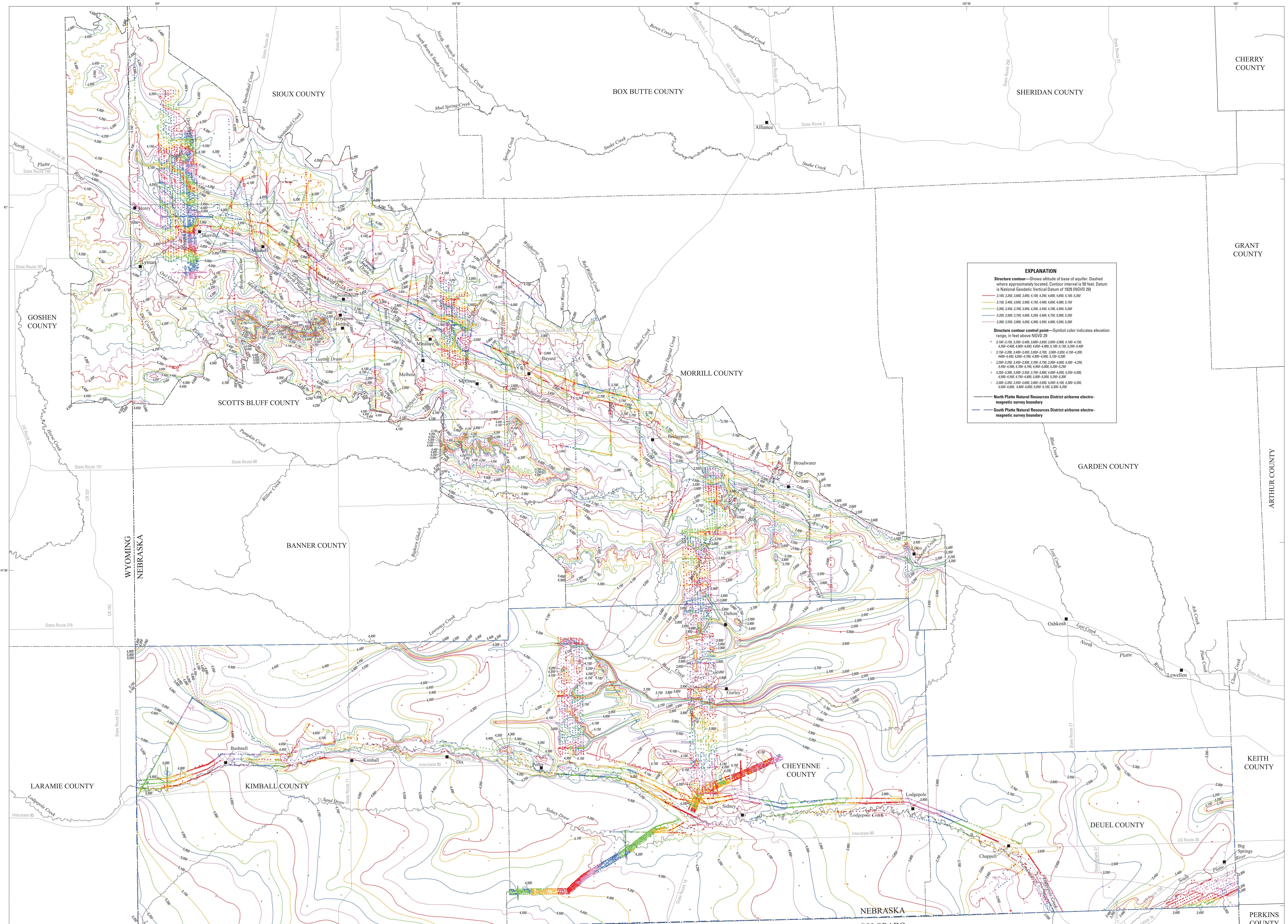

Figure 2. Elevation of the base-of-aquifer surface for parts of the North Platte Natural Resources District and the South Platte Natural Resources District, 2014.

This report is available at *http://dx.doi.org/10.3133/sim3310*.

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Base of Principal Aquifer for Parts of the North Platte, South Platte, and Twin Platte Natural Resources District, Western Nebraska

By

Christopher M. Hobza, Jared D. Abraham, James C. Cannia, Michaela R. Johnson, and Steven S. Sibray