

Chapter 1

Introduction

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The Wyoming State Engineer's Office (SEO) published the first State Framework Water Plan in 1973 under the Wyoming Water Planning Program. The publication presented a water resources plan for the entire state of Wyoming and included summary water plans for each of the state's seven major river drainages. In 1975, the Wyoming Legislature established the Wyoming Water Development Commission (WWDC) and Wyoming Water Development Office (WWDO) to coordinate planning, development, and project management efforts for water and related land resources. Between 1979 and 1995, the WWDO completed several major river basin planning studies.

The development of the present State Water Planning Process began in 1997 when the state legislature directed WWDC to conduct a feasibility study in collaboration with the University of Wyoming (UW) and the SEO. The study included public input and compilation of a statewide water inventory. Based on the feasibility study, the Wyoming Legislature accepted the recommended planning framework to update the original 1973 State Framework Water Plan, funding the State Water Planning Process in 1999, and providing funding to:

- inventory the state's water resources and related lands
- summarize the state's present water uses and project future water needs
- identify alternatives to meet projected future water needs
- direct water resource planning for the state of Wyoming for a 30-year timeframe

The Wyoming Framework Water Plan was completed between 2001 and 2006 (WWC Engineering and others, 2007), and summarized the separate water plans for Wyoming's seven major river basins (fig. 1-1).

Technical memoranda in the previous Powder/Tongue River Basin Water Plan (HKM Engineering and others, 2002a) and Northeast Wyoming River Basin Water Plan (HKM Engineering and others, 2002b) contain groundwater resource investigations that thoroughly examine the basins' resources and usage (see Technical Memorandum N in both reports). This Available Groundwater Determination represents the most current assessment of the groundwater resources in the Powder/Tongue and Northeast River basins, updating and expanding the information presented in the 2002 groundwater investigations. The data contained in this

memorandum are a compilation of existing information obtained by several state and federal agencies. While original maps and tables were developed, and existing maps and tables were updated and modified, no original research was conducted for this memorandum.

The format of this update follows the general layout of other recent groundwater determinations co-authored by the Wyoming State Geological Survey (WSGS) and U.S. Geological Survey (USGS) for the Green River Basin (2010), the Wind/Bighorn River Basin (2012), the Platte River Basin (2013), the Bear River Basin (2014), and the Snake/Salt River Basin (2014). This memorandum incorporates much of the content of these five previous studies, frequently without citation. Previous water plans are available on the WWDC website at: <http://waterplan.state.wy.us/>.

1.1 INTERAGENCY AGREEMENT AND SCOPE

The WWDC and WSGS entered into an Interagency Agreement in July 2015 to update the groundwater information contained in the previous Powder/Tongue River Basin Water Plan (HKM Engineering and others, 2002a) and Northeast Wyoming River Basin Water Plan (HKM Engineering and others, 2002b). The two agencies agreed to consolidate groundwater information for the two river basin plans into one large report, henceforth referred to as the Northeast River Basins (NERB) Plan. The geographical area covered by this report encompasses the northeast quarter of Wyoming and includes the drainages of the Little Bighorn, Tongue, Powder, Little Powder, Belle Fourche, Little Missouri, Cheyenne, and Upper Niobrara rivers. The agreement outlines the following tasks to update the previous water plans:

- Identify the major (i.e., most widely used) aquifers in the Northeast River Basins:
 - The USGS identified aquifers and confining units in a hydrostratigraphic nomenclature chart (fig. 7-8). Based on these analyses, the geologic units mapped on plate 1 and described in appendix A were organized into a comprehensive hydrostratigraphic chart and surface hydrogeology map for the NERB (pl. 2). In some cases, two or more minor aquifers that are hydrologically connected are grouped and treated as a single combined hydrogeologic unit. The general geology of the Northeast River Basins is discussed in chapter 4, and individual aquifers are detailed in chapter 7.

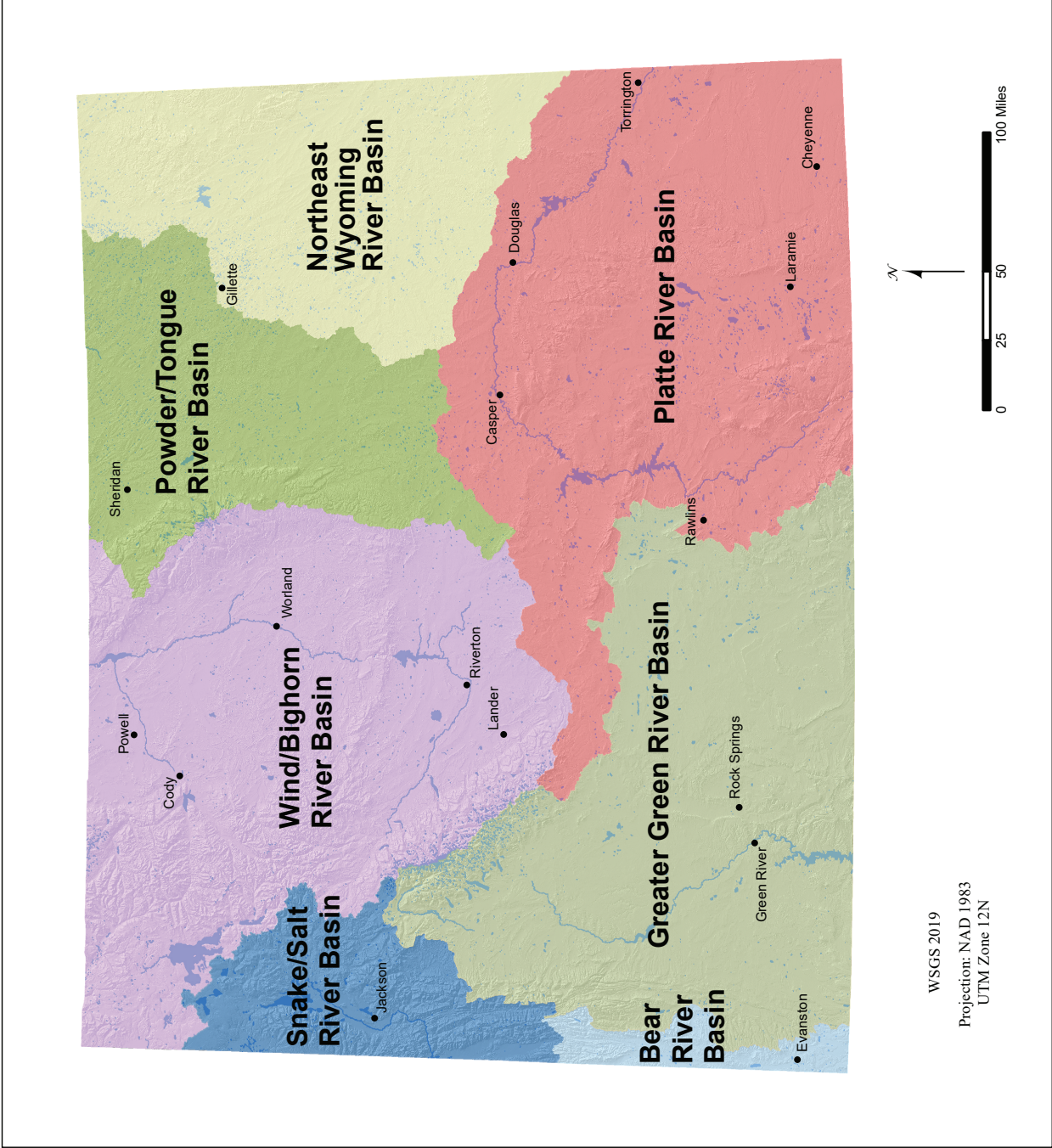


Figure 1-1. Major drainage basins, Wyoming.

- Define the three-dimensional extent of the aquifers:
 - Plate 2 is a map of the outcrop areas for the Northeast River Basins' aquifers and confining units. Nine cross sections (figs. 4-3 through 4-11) illustrate the subsurface configuration of the geologic units that constitute the hydrogeologic units at selected locales within the NERB.
- Describe the following hydraulic, hydrogeologic, and hydrogeochemical properties of the aquifers and confining units:
 - Physical characteristics— chapters 4 and 7 discuss the lithologic and hydrogeologic characteristics of the hydrogeologic units identified in plate 2.
 - Water chemistry with comparisons to applicable state and federal regulatory standards by class of use—chapters 5 and 7 contain extensive discussions of basin water quality with comparisons to regulatory standards. Statistical analyses of water chemistry are presented in appendices E through H.
 - Principal potential pollutants—chapter 5 contains a discussion of potential pollution sources. Maps of these facilities are provided in figures 5-4 through 5-10.
- Estimate the quantity of water in the aquifers:
 - Data sufficient for a basin-wide, aquifer-specific assessment of groundwater quantity is not available. The complex geology of the Northeast River Basins does not lend itself to the general assumptions about aquifer properties, geometry, and saturated thickness that a plausible estimate of total and producible groundwater resources requires. The most important aquifers in the Northeast River Basins, including the Wasatch, Fort Union, and Madison formations, have been described in numerous, specific studies completed by the USGS (chap. 2) and WWDC (app. B) that are more comprehensive and relevant than a summary estimate. Groundwater resource estimates are addressed in this technical memorandum by analysis of recharge (chap. 6) and basin-wide water balances (chap. 8).
- Describe the aquifer recharge areas:
 - Plate 2 is a map of outcrop areas of aquifers and confining units in the Northeast River Basins. Maps depicting the outcrop areas used to calculate the annual rate of recharge for specific aquifers and groups of aquifers throughout the Northeast River Basins are provided in figures 6-1 through 6-6. Section 5.1 and chapter 6 discuss recharge.
- Estimate aquifer recharge rates:
 - Maps depicting average annual precipitation (fig. 3-3) and estimated recharge rates (fig. 5-2) over the NERB are presented in this technical memorandum. Existing annual recharge rates were multiplied by aquifer outcrop areas (figs. 6-1 through 6-6) to estimate a range of annual recharge volumes for individual and combined aquifers. The results of these estimates are summarized in tables 6-1 through 6-3 and discussed in section 6.2. Figure 6-7 represents recharge as a percentage of precipitation, and section 6.2 describes how recharge efficiency varies by individual and combined aquifers overall within the NERB.
- Discuss the concepts of “safe yield” and “sustainable yield,” and describe implications of hydrologically connected groundwater and surface water:
 - The concept of “safe yield” is discussed in section 5.1.4. This report provides estimates of total recharge (average annual) for the NERB in chapter 6 and compares these recharge estimates to current groundwater withdrawals in chapter 8.
- Describe and evaluate existing groundwater studies and models:
 - Existing groundwater models are identified and evaluated, and recommendations for future groundwater modeling in the NERB are discussed in chapter 7.
- Identify future groundwater development opportunities to satisfy projected agricultural, municipal, and industrial demands:
 - Several approaches to address future groundwater development potential are discussed throughout this report.
 - General and aquifer-specific hydrogeology relative to groundwater development potential is discussed in chapters 5 and 7.

- Figures 8-1 through 8-7 show wells permitted by the SEO in the Northeast River Basins through October 7, 2015. These figures include selected groundwater permit statistics and illustrate historic groundwater development patterns relative to a sub-region's hydrogeologic unit outcrop patterns. Existing groundwater development in the NERB is discussed in chapters 7 and 8.
- A summary of groundwater development studies and projects in the NERB, sponsored by the WWDC, is included in appendix B. The development potential of specific aquifers, based on information compiled from these and other studies, is described in chapter 7.
 - Groundwater development prospects identified in the groundwater resource investigations of the previous Powder/Tongue River Basin Water Plan (HKM Engineering and others, 2002a) and Northeast Wyoming River Basin Water Plan (HKM Engineering and others, 2002b) are discussed in chapter 9.
 - Current WWDC and SEO projects related to groundwater development in the NERB are discussed in chapter 9.
- On behalf of WWDC/WWDO, WRDS will feature the associated deliverables on the WWDC website at: <http://waterplan.state.wy.us/>.

The WWDC, the water development and water planning agency for Wyoming, administers publicly funded development, construction, rehabilitation, and related water projects through its professional and support staff at the WWDO.

The WSGS is a separate operating agency under the executive branch of state government (Wyoming State Statutes 9-2-801 and 9-2-803 through 9-2-810). The WSGS' purposes are: 1) to study, examine, and understand the geology, mineral resources, and physical features of the state; 2) to prepare, publish, and distribute (free or for a nominal price) reports and maps of the state's geology, mineral resources, and physical features; and 3) to provide information, advice, and services related to the geology, mineral resources, and physical features of the state. The survey's mission is to "promote the beneficial and environmentally sound use of Wyoming's vast geologic, mineral, and energy resources, while helping protect the public from geologic hazards." By providing accurate information and expanding knowledge through the application of geologic principles, the WSGS contributes to the economic growth of the state. WSGS hydrogeologists conduct research, compile data, create and distribute maps and reports, and address inquiries to assist citizens, industry, and state and federal agencies in planning, decision-making, and analysis of water issues.

The USGS provides data, maps, reports, and other scientific information to help individuals and local and state governments manage, develop, and protect the United States' water, energy, mineral, and land resources. The agency's mission is to "provide reliable scientific information to describe and understand the earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life." Toward these goals, the USGS employs experienced scientists and support staff from a wide range of disciplines.

The WRDS is a clearinghouse for hydrological data. The WRDS is funded by the WWDO to provide a variety of services, including the online provision of groundwater resources information, maps, and publications.

The SEO and WWDO cooperate on many projects. SEO personnel attend meetings on river basin planning and other WWDC projects. WWDC-funded groundwater development projects generally require permits

I.2 AGENCY PARTICIPATION

This technical memorandum is the result of a cooperative effort by the WWDC/WWDO, WSGS, USGS, and the Water Resources Data System (WRDS). The SEO and the Wyoming Department of Environmental Quality (WDEQ) contributed significant datasets for developing some of the figures presented in this technical memorandum.

- The WWDO and WRDS provided WSGS with overall program guidance and standards, software, and format requirements for deliverables (e.g., maps, databases, metadata, tables, and graphs).
- WSGS was the primary compiler of the information developed in chapters 1 through 6 and chapters 8 and 9.
- The USGS, under contract to the WSGS, compiled the information used in chapter 7 and section 5.6.1.
- The WSGS and USGS cooperated on sections of chapters 5 and 9.

from both the SEO and WDEQ (K. Clarey, WWDO, personal commun., 2017).

1.3 LEGAL AND INSTITUTIONAL FRAMEWORK

Wyoming laws that govern the appropriation, development, and beneficial use of water resources are based on the doctrine of prior appropriation, commonly stated as “first in time is first in right” (Jacobs and others, 2003). This means that, during periods of limited supply, the first party to put a source of water to beneficial use has a “priority” water right honored prior to those of other, later users. An exception is that municipalities can obtain water rights from earlier priority uses through eminent domain (Wyoming State Statutes 1-26). The Wyoming Constitution establishes that all natural waters are property of the state. Therefore, a water right does not grant ownership, but only the right to use water for beneficial purposes. Use of water resources for domestic and live-stock purposes customarily takes precedence over other uses. In Wyoming, water rights are attached to the land and can be transferred. The laws and regulations pertaining to the appropriation, development, and beneficial use of groundwater are administered by the SEO and Board of Control, a panel comprised of the superintendents of the four state water divisions and the state engineer. Most of the Northeast River Basins area is included in SEO Water Division II; the small Niobrara River Basin lies in Division I. The SEO website provides summary documents that examine pertinent aspects of Wyoming water resource law at: <http://seo.wyo.gov/documents-data>.

1.3.1 Wyoming water law—groundwater appropriation, development, and use

Groundwater within the state is owned and controlled by the State of Wyoming. Under Wyoming law, groundwater includes any water (including geothermal waters) under the land surface or under the bed of any body of surface water (Jacobs and others, 2003). The SEO is authorized for the permitting and orderly development of groundwater in Wyoming and has shared authority for protecting groundwater resources from waste and contamination. The updated Wind/Bighorn River Basin Water Plan (MWH and others, 2010) provides the following discussion of Wyoming water law specific to groundwater:

“Wyoming’s groundwater laws were originally enacted in 1945 and amended in 1947. These laws were replaced by new groundwater laws on March 1, 1958, which were then amended in 1969. Groundwater is administered on a permit basis.

The acquisition of groundwater rights generally follows the same permitting procedures as surface water rights, except that a map is not required at the time of permit application. Applications are submitted to and approved by the WSEO [sic] prior to drilling a well. With the completion of the well and application of the water to a beneficial use, the appropriation can then be adjudicated. The issuance of well permits carries no guarantee of a continued water level or artesian pressure.”

“As with surface water rights, groundwater rights are administered on a priority basis. For all wells drilled prior to April 1, 1947, a statement of claim process was followed to determine the priority date of the well. For wells drilled between April 1, 1947 and March 1, 1958, the priority date is the date the well was registered. For wells drilled after March 1, 1958, the priority date is the date the application was received at the WSEO [sic].”

“Domestic and stock wells are those wells used for non-commercial household use, including lawn and garden watering that does not exceed one acre in aerial extent, and the watering of stock. The yield from these wells cannot exceed 25 gallons per minute (gpm). Prior to the 1969 amendment, domestic and stock wells were exempt from the requirement to obtain a permit and held a preferred right over other wells. The 1969 amendment established priorities for domestic and stock wells similar to those for other wells. The Groundwater Division [of the SEO] also issues permits for spring developments where the total yield or flow of the spring is 25 gpm or less and where the proposed use is for stock and/or domestic purposes.”

1.3.2 Interstate agreements

Wyoming is a “headwater” state. In most river basins, major portions of stream outflows into neighboring states originate in Wyoming (WWC Engineering and others, 2007). However, large volumes of these Wyoming sourced streamflows are allocated to priority water rights holders in downstream states. Streamflow allocations for most of Wyoming’s rivers are defined by interstate compacts, international treaty, or court decree (SEO, 2006). The more recent agreements, notably in the Platte River and Bear River basins, recognize groundwater extraction can deplete streamflows, and include provisions limiting groundwater use in Wyoming.

The river basins examined in this report consist of the Wyoming portions of the Little Bighorn, Tongue, Powder, and Little Powder rivers of the Yellowstone River system, and the drainage basins of the Little Missouri,

Belle Fourche, Cheyenne, and Niobrara rivers. Small areas in Montana, South Dakota, and Nebraska that are tributary to these Wyoming drainages are also included in some analyses presented in this report (fig. 3-1).

Three interstate stream compacts regulating the river basins in northeast Wyoming include:

- The Yellowstone River Compact of 1950, signed by Montana, Wyoming, and North Dakota, which regulates the Little Bighorn, Tongue, Powder, and the Little Powder Rivers in Wyoming, designates the division of waters and unallocated flows among the signatory states, and exempts future stock and domestic uses from provisions of the compact. The compact considers surface flows only and does not place any regulation on the allocation or development of groundwater.
- The Belle Fourche River Compact of 1943, signed by Wyoming and South Dakota, governs surface water rights and use in the Belle Fourche River Basin in Wyoming but does not contain restrictions on groundwater use in either state.
- The Upper Niobrara River Compact of 1962, signed by Wyoming and Nebraska, regulates Wyoming's use of the Niobrara River by defining storage and streamflow rights and priority dates. This compact also establishes the legal foundation for future groundwater apportionment in the Niobrara Basin.

All interstate compacts regulating streamflows in Wyoming are available for review at: <http://seo.wyo.gov/interstate-streams>. Appendix D contains copies of the Yellowstone, Belle Fourche, and Niobrara compacts.

1.3.3 Wyoming water law— groundwater quality

The Denver office of the U.S. Environmental Protection Agency (EPA) Region 8 has primary control (primacy) over Wyoming's public drinking water supplies. Wyoming is the only state in which EPA has primacy over drinking water systems. The EPA monitors water quality for several hundred public water systems in Wyoming. Information about Wyoming's public drinking water systems is available on the EPA Wyoming Drinking Water website at: <https://sdwiser8.epa.gov/Region8DWWPUB/index.jsp>.

Except on the Wind River Indian Reservation, the WDEQ enforces groundwater quality regulations under the Wyoming Environmental Quality Act, with guidance from the Wyoming Environmental Quality Council.

The WDEQ administers provisions of the federal Clean Water Act Amendment of 1972 (Section 208) that provide for water quality management by state and local governments, as well as provisions of the Federal Water Pollution Act, by developing a State Water Quality Plan approved by the EPA. In general, operations that cause groundwater contamination under the jurisdiction of the Wyoming Oil and Gas Conservation Commission (WOGCC), U.S. Bureau of Land Management (BLM), EPA, or U.S. Forest Service are referred to the WDEQ. The WOGCC has jurisdiction over Class II underground injection wells (chapter 5) dedicated to disposal of produced water from state and federal oil and gas leases.

1.3.4 Other agencies

The U.S. Bureau of Reclamation (BOR), an agency under the U.S. Department of the Interior, oversees and manages water resources specifically related to the operation of numerous water diversions, delivery, storage, and hydroelectric power generation projects built by the federal government throughout the western United States. The BOR cooperates with the SEO and the WWDC, but as a federal agency, has autonomy to execute some programs unilaterally. The BOR coordinates releases from Wyoming's reservoirs with the SEO (K. Clarey, WWDO, personal commun., 2017). Although not a primary area of concern, the BOR and the following other agencies are occasionally involved in groundwater resource issues:

- Wyoming Department of Agriculture
- U.S. Department of Agriculture
- U.S. National Park Service
- U.S. Army Corps of Engineers
- U.S. National Resources Conservation Service
- U.S. Office of Surface Mining, Reclamation, and Enforcement
- U.S. Bureau of Ocean Energy Management and the Bureau of Safety and Environmental Enforcement
- U.S. Department of Energy
- U.S. Nuclear Regulatory Commission

I.4 AUTHORSHIP

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