PREPARED IN COOPERATION WITH THE
WYOMING STATE ENGINEER

CHEMICAL QUALITY OF GROUND WATER

The quality of ground water ranges from good to highly mineralized. Drinking Water Standards of the U.S. Public Health Service (1962) recommend that dissolved solids in water used for drinking and culinary purposes on interstate carriers should not exceed 500 mg/l (milligrams per liter), or no more than 1,000 mg/l where water of better quality is not available.

Beath and others (1953) suggest the following classification as a guide for evaluating stock water in Wyoming:

Dissolved solids (mg/l)	*Classification*
Less than 1,000	Good
1,000 to 3,000	Fair (usable)
3,000 to 5,000	Poor (usable)
5,000 to 7,000	Very poor (questionable)
More than 7,000	Not advisable

Dissolved solids can be expected to be less than 100 mg/l in water from igneous and metamorphic rocks of Precambrian age and from intrusive igneous rocks of Tertiary(?) age. However, rocks of these types yielding water to wells or springs are restricted to areas of outcrop in the higher elevations of the Bighorn Mountains and to small areas of outcrop in the Black Hills.

Analyses of water from Paleozoic rocks show dissolved solids ranging from less than 200 to nearly 4,000 mg/l except for one composite water from both the Tensleep Sandstone and the Goose Egg Formation in Johnson County that contained nearly 8,000 mg/l dissolved solids. Of 63 available analyses, 34 show dissolved solids less than 500 mg/l, 45 less than 1,000 mg/l, and 18 more than 1,000 mg/l. Fifteen analyses of water from the Pahasapa Limestone show dissolved solids ranging from 248 to 588 mg/l. Fifteen analyses of water from the Tensleep Sandstone show dissolved solids ranging from 192 to 2,920 mg/l—all but three waters, however, contain less than 500 mg/l. Twenty-two analyses of water from the Minnelusa Formation show dissolved solids ranging from 218 to 3,900 mg/l.

Analyses of water from Mesozoic rocks show dissolved solids ranging from 218 to about 4,000 mg/l, except for one water from the Cody Shale in Johnson County that contained more than 11,000 mg/l dissolved solids and water from a spring flowing from the Spearfish Formation along Salt Creek in Weston County that contained more than 30,000 mg/l dissolved solids. Of 134 available analyses, 14 show dissolved solids less than 500 mg/l, 48 less than 1,000 mg/l, and 86 more than 1,000 mg/l. In general, water from Mesozoic rocks is more mineralized than water from Paleozoic rocks. The Lance Formation, Fox Hills Sandstone, Cloverly Formation, and Inyan Kara Group contain water with lower dissolved solids than other formations of Mesozoic age, although in and near the outcrop some formations contain water with relatively low dissolved solids.

Analyses of water from Cenozoic rocks show dissolved solids ranging from less than 100 to more than 5,000 mg/l. Of 258 available analyses, 55 show dissolved solids less than 500 mg/l, 133 less than 1,000 mg/l, and 125 more than 1,000 mg/l. Most waters in the Arikaree and White River Formations contain less than 500 mg/l dissolved solids. Water quality in the Wasatch and Fort Union Formations ranges widely and appears to correlate with the permeability of the water-bearing sand and its proximity to the outcrop; no relation of water quality to depth is apparent. Water in the alluvium is variable in quality and generally is less mineralized near the mountains than in the central part of the basin.

Sodium, sulfate, and bicarbonate are the dominant ions in most ground water. Water from many formations is excessively hard. Iron is characteristically a problem in water from the Wasatch and Fort Union Formations of Tertiary age as well as from several sandstone formations of Cretaceous age. Fluoride content is high in some water from the Fox Hills Sandstone.

Significant mineral hazards that affect the suitability of water for irrigation are the dissolved solids (salinity), boron, percent sodium, and sodium content relative to calcium and magnesium content. If the bicarbonate content is high, calcium and magnesium tend to precipitate as carbonates, and the relative proportion of sodium to calcium and magnesium is increased. Sodium is characteristically high in water from a number of formations in the Powder River Basin—most notable are the Wasatch and Fort Union Formations of Tertiary age, and the Lance, Mesaverde, Cody, Frontier, and Cloverly Formations, Fox Hills Sandstone, and Inyan Kara Group of Cretaceous age. Before water supplies are developed and used for irrigation, local agricultural agencies should be contacted concerning the suitability of the water in relation to the soil and crops to be irrigated.

USE OF WATER

The predominant and most widespread use of ground water is for stock and domestic purposes. No estimate was made of the number of wells or the amount of water used for stock and domestic purposes.

Very little ground water is used for irrigation except on lawns and small gardens. The largest effort toward using ground water on a large scale for irrigation was in T. 44 N., R. 72 W. Well yields were large enough; however, the effort failed because the quality of the water was too poor for long-term use on the land.

Industrial use includes oil-well and coal-mining operations and highway construction. Data from Biggs and Koch (1969) on active waterflood projects show that injection of water for waterflooding in December 1967 exceeded 600,000 barrels (25 million gallons) daily in oilfields within the report area. Total cumulative water injection for these projects to January 1, 1968 was 1.24 billion barrels (52 billion gallons). Some of this water was produced with the oil, but most came from water wells in the Madison Limestone, or the partly equivalent Pahasapa Limestone. Other formations from which water was obtained for waterflooding include the Mesaverde and Cloverly Formations and the Tensleep Sandstone in the western and southern parts of the area, and the Minnelusa, Lakota, and Lance Formations, and the Fox Hills Sandstone in the eastern part. The Fox Hills, Lance, and Fort Union yield water for waterflooding in the central part of the basin.

Several towns obtain municipal water supplies from wells. In the Black Hills, Newcastle, Osage, and Upton obtain supplies from the Pahasapa Limestone, and Sundance and Hulett obtain supplies from the Minnelusa Formation. Moorcroft has wells in the Lance Formation, Gillette has wells in the Wasatch and Fort Union Formations, and Edgerton has wells in the Fox Hills Sandstone. Casper and Midwest have wells in the alluvium of the North Platte River valley.

Newcastle and Gillette each report ground-water use of more than 200 million gallons per year, and Casper about 2.5 billion gallons per year (Wyoming Water Resources Research Institute, 1968). Ground-water use for other towns is not available.

EXPLANATION

WELL AND SPRING DATA

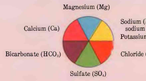
Nonflowing well — Flowing well — Spring — Drilldem test

12abc.....Section number segment of well number. Explanation of well numbers given in text
W51.....Depth to water level, in feet below land surface (R after number indicates water level reported by owner or driller)
F10.....Flowing yield of well or spring, in gallons per minute (R after number indicates yield reported by owner or driller)
D750.....Depth of well, in feet
Kfh.....Geologic source of water
(Ki).....If shown, indicates minor aquifer yielding water to well

GEOLOGIC SOURCE SYMBOLS

Qal.....Alluvium
Qg.....Glacial deposits
Ta.....Arikaree Formation
Twr.....White River Formation
Tw.....Wasatch Formation
Tf.....Fort Union Formation
Ti.....Intrusive rocks
Kl.....Lance Formation
Kfh.....Fox Hills Sandstone
Kle.....Lewis Shale
Kmv.....Mesaverde Formation
Kpi.....Pierre Shale
Kc.....Cody Shale
Kcl.....Carlile Shale
Kf.....Frontier Formation
Km.....Mowry Shale
Knc.....Newcastle Sandstone
Kcv.....Cloverly Formation
Kik.....Inyan Kara Group
Kfr.....Fall River Formation
Kla.....Lakota Formation
Jm.....Morrison Formation
Js.....Sundance Formation
Ŧg.....Gypsum Spring Formation
Ŧc.....Chugwater Formation
Ŧsp.....Spearfish Formation
Ŧcg.....Goose Egg Formation
Pm.....Minnekahta Limestone
Po.....Opeche Shale
PŦŦ.....Tensleep Sandstone
PMa.....Amsden Formation
PIPm.....Minnelusa Formation
Mm.....Madison Limestone
Mp.....Pahasapa Limestone
DŠd.....Deadwood Formation
Ꞓf.....Flathead Sandstone
pЄr.....Precambrian rocks

CHEMICAL-QUALITY DATA



Kfh
6050', if shown, indicates geologic source and maximum depth of sampled zone, in feet below land surface

The chemical type of the water is shown by segments of a colored circle; the size of the circle denotes the range in dissolved solids. Segment divisions are diagrammatic with the major cation relation shown in the top half of the circle and the major anion relation shown in the bottom half. The following procedure was followed in determining the water type:

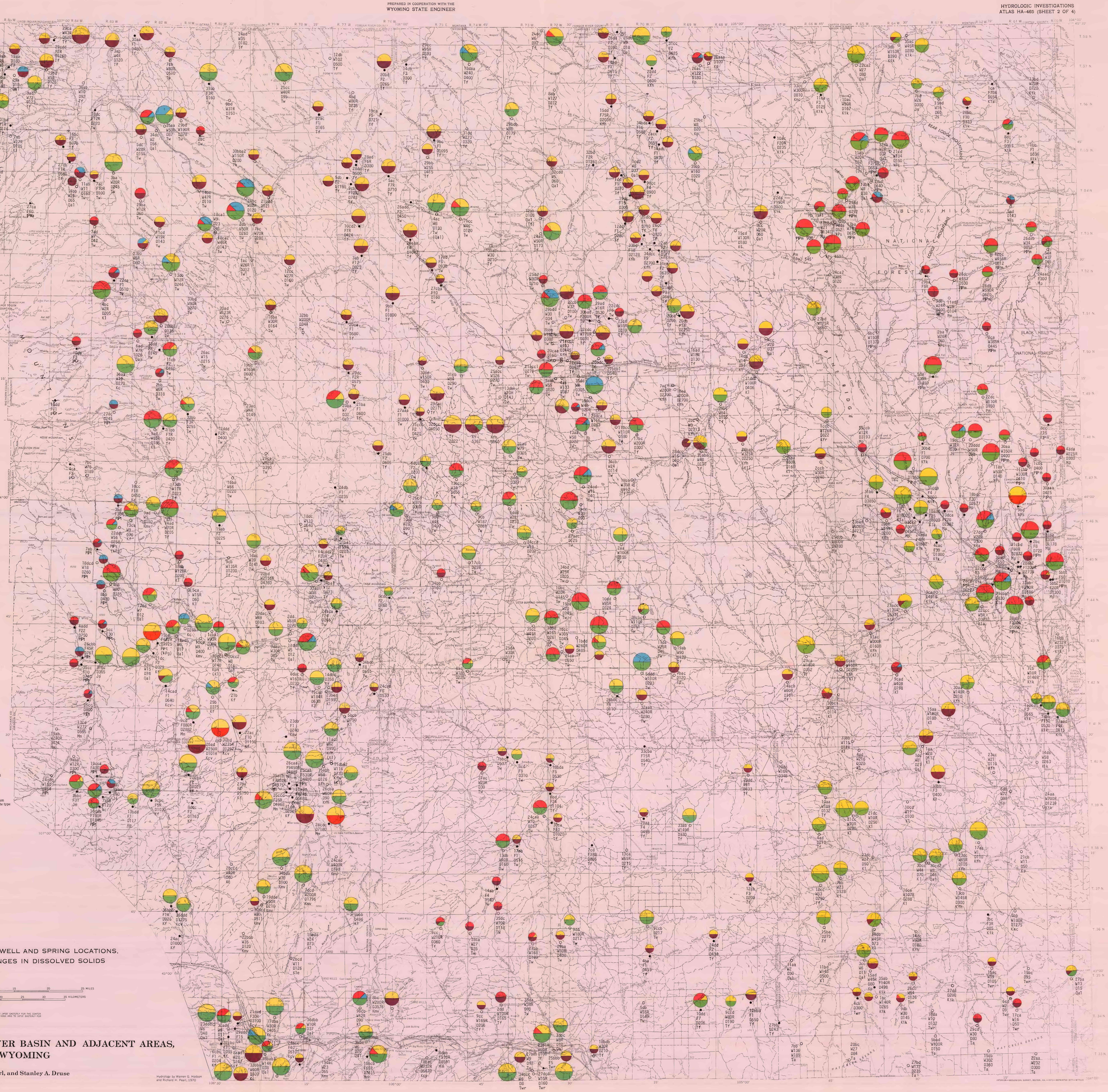
1. The sum of the major cations-calcium, magnesium, and sodium (or sodium plus potassium)-in milliequivalents per liter was taken to be 100 percent and the percentage of each was calculated from that base; similarly, the major anions-bicarbonate (or bicarbonate plus carbonate), sulfate, and chloride-were calculated from a base of 100 percent.
2. Where one cation constitutes 50 percent or more of the total cations and one anion constitutes 50 percent or more of the total anions, that cation and that anion designate the water type. For example, if sodium is 60 percent of the total cations and sulfate is 75 percent of the total anions, the water is classified as a sodium sulfate water. Examples are diagrammed below.
3. If no ion constitutes as much as 50 percent of the total cations, or anions, the ion with the highest percentage is given two-thirds of the semicircle and is named first and the ion with the second highest percentage follows as a subsidiary term. Rarely would all three cations, or anions, be virtually equal in percentage.

Examples

Calcium	30 percent	17 percent	43 percent
Magnesium	10	38	19
Sodium	60	45	38
Bicarbonate	20	10	46
Sulfate	75	28	41
Chloride	5	62	13
	Sodium sulfate type	Sodium magnesium chloride type	Calcium sodium bicarbonate sulfate type

Less than 500 — 500-1000 — 1000-2000 — More than 2000

Ranges in dissolved solids (in milligrams per liter)



HYDROLOGIC MAP SHOWING SELECTED WELL AND SPRING LOCATIONS, CHEMICAL TYPES OF WATER, AND RANGES IN DISSOLVED SOLIDS

WATER RESOURCES OF THE POWDER RIVER BASIN AND ADJACENT AREAS, NORTHEASTERN WYOMING

By
Warren G. Hodson, Richard H. Pearl, and Stanley A. Druse

1973

Base from U.S. Geological Survey Arminto, Casper, Gillette, Newcastle, Sheridan, and Torrington 1:250,000 (1954-62)

Hydrology by Warren G. Hodson and Richard H. Pearl, 1970

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