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GROUND WATER IN THE MISSOURI RIVER BASIN1/

By

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Ground water is the chief source of water supply in the Missouri River Basin for public waterworks, railroads, and domestic and stock use. The water supply for up to 95 percent of the municipalities in most of the Basin States is obtained from ground-water reservoirs. Ground water is also used extensively for irrigation, air conditioning, and industrial purposes, and it is the chief source of natural low flow of streams. The use of great areas of range land is dependent upon the availability of ground water for stock use. Many lakes and streams, some of which are the most productive of fish in the Basin and sustain great numbers of wildfowl, are fed by discharge from ground-water reservoirs. The yield from wells in the Basin ranges from a few gallons to more than 2,000 gallons per minute. The depth of productive wells ranges from a few feet to several thousands of feet.

The occurrence of ground water in the Basin may, geologically and for convenience, be discussed under seven broad regional subdivisions: (1) the Glacial Drift region, (2) the Black Hills Cretaceous region, (3) the Montana Eocene-Paleocene-Cretaceous region, (4) the Rocky Mountain region, (5) the Plateau region, (6) the Great Plains region, and (7) the South Central Paleozoic region.

The Glacial Drift region embraces, in general, that part of the Basin lying in northern Montana, northern and eastern North Dakota, eastern South Dakota, eastern Nebraska, western Iowa, northeastern Kansas, and northern Missouri. The glacial drift, which mantles the surface throughout most of the area, is composed of a heterogeneous mixture of clay, silt, sand, gravel, and boulders and ranges in total thickness from a few feet to several hundreds of feet. There is a wide range in both the lithology and the age of the bedrock that underlies the glacial drift. Within the glacial mantle are many lenticular deposits of permeable sand and gravel, buried stream channels, and ancient lake beds, which generally are known only where they are penetrated by wells. Much ground water is recovered from the permeable beds in the glacial drift and from the alluvium in the valleys of present-day streams. Many untapped and unknown deposits, some of which may be extensive, undoubtedly exist. Many wells that tap the underlying bedrock encounter water under artesian pressure, which in some places is sufficient to make the wells flow at the land surface. A great majority of these flowing wells are uncontrolled, wasting large quantities of water and dissipating pressure which can never be fully restored. It has been estimated that such wastage in the James River valley in South Dakota alone amounts to 15,000 gallons a minute or nearly 25,000 acre-feet per year (enough each year to cover 25,000 acres with water 1 foot deep).

The Black Hills Cretaceous region embraces part of South Dakota west of the Missouri River and small adjoining areas in Wyoming, Nebraska, and North Dakota. Except for the Dakota sandstone, which lies a thousand or more feet below the land surface in most of the area and yields water of poor quality in some places, unproductive Cretaceous formations underlie all the area except the Black Hills. In some parts of the area the water level in artesian wells approaches the land surface, and in topographically favorable locations flowing wells can be obtained. Shallow supplies of ground water are essentially unavailable in this region because the Pierre shale or shales of the White River group (of Oligocene Age) underlie most of the area; where these shales are exposed or are close to the surface, no water or very meager supplies of poor quality water are obtainable. In the Black Hills

1/ Released with the permission of the Director of the U. S. Geological Survey.

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ground water is obtained from sources that range from pre-Cambrian crystalline rocks to Cretaceous and Tertiary sedimentary rocks. Studies of ground-water conditions in the region as a whole have been of a very general nature; the developed supplies are meager and of poor quality. The future potential growth of the area depends in a large measure on the discovery and development of all possible ground-water supplies.

The Montana Eocene-Paleocene-Cretaceous region includes principally the Yellowstone River drainage area below the mouth of the Big Horn River, the part of North Dakota lying south and west of the Missouri River, and the northwestern part of South Dakota. The Wasatch (Eocene), Fort Union (Paleocene), and Lance or Hell Creek (late Cretaceous) formations underlie most of the region, and these overlie the Pierre shale, which yields no water, or meager supplies generally of poor quality. Where the Fort Union and Lance formations are present, fairly good water in quantities adequate for domestic and livestock supplies and for small municipal supplies is obtained from sandstone and coal beds. Locally, a limited amount of ground water of generally poor quality is found at shallow depth in terrace gravels and alluvial sediments of the stream valleys. In the northern part of the region a little water is yielded by the glacial drift.

The Rocky Mountain region includes two areas: the part of the Missouri River Basin that lies above Great Falls, Mont., and the upper reaches of the Yellowstone and Big Horn Rivers, and an area that includes north-central Colorado and a part of southeastern Wyoming. The region is chiefly mountainous and is underlain by a great variety of rocks with complicated and diverse structure. In the extensive intermontane valleys and plains, considerable water of good quality is available in places from valley fill, which is chiefly alluvial sand and gravel and the outwash deposits of mountain glaciers. Large ground-water reservoirs probably exist in the part of the region immediately above the junction of the Gallatin, Madison, and Jefferson Rivers. Mountain springs are common. Little study except on a very general basis has been made of the ground-water conditions of this region.

The central parts of Montana and Wyoming, which lie in the Plateau region, are arid or semiarid and are underlain by consolidated sedimentary formations that range in age from Paleozoic to Tertiary. The formations are sufficiently warped and broken to produce a close relation between rock structure and the occurrence of ground water. Generally, ground water is not plentiful and much of it is of poor quality. Locally, sandstone aquifers can be reached economically and yield adequate supplies; in some places the ground water is under sufficient artesian pressure to flow at the land surface. Productive water-bearing sands and gravels of Pleistocene or Recent age occur in some of the stream valleys and terraces. Only meager data on the ground waters of this region are available.

Most of Nebraska, northern Kansas, eastern Colorado, and eastern Wyoming lie in the Great Plains region and are underlain by Tertiary and Pleistocene sands and gravels, which yield moderate to large quantities of good water to relatively shallow wells. Most river valleys contain comparatively thick sand and gravel deposits of Pleistocene or Recent age, which yield large quantities of good water. The Sand Hills area of central Nebraska, one of the largest and most productive subterranean reservoirs in the United States, sustains a steady flow in several Nebraska streams, but otherwise is little used or understood. The Great Plains region is the most productive ground-water region in the Basin, and much future development of the ground-water resources can be made. It is in this region that most of the irrigation by pumping from wells has occurred and where perhaps the greatest potential in the Basin for that purpose exists. Relatively, the greatest amount of ground-water information for the Basin is that on the Great Plains region, but even here only a small percentage of the knowledge necessary to develop and conserve fully the ground-water resources, and to correlate their development with that of surface water, is yet available.

East-central Kansas and the central part of Missouri lie in the South Central Paleozoic region. There, small supplies of ground water are obtained from the Paleozoic sandstones and limestones; the water is of poor quality, especially that from deep Paleozoic rocks. However, large supplies of usable water are obtained from glacial outwash and other alluvial sands and gravels in many of the stream valleys.

During the last half-century, studies of the occurrence, movement, and recovery of ground water in the Basin have been made more or less sporadically. Most of these studies were made because of pressing local need; essentially none of them have been continuous, of extensive areal extent, of long duration, or exhaustive. In Nebraska and Kansas, where cooperative studies between the States and the United States Geological Survey have been carried on for a number of years, the knowledge of ground water has been advanced the farthest; much less progress has been made in other parts of the Basin. Ground-water studies are also being made cooperatively by the U. S. Geological Survey in Colorado, Wyoming, North Dakota, and Iowa. In South Dakota and Missouri no cooperative projects are under way but studies are being made by State agencies; also, some work is being done in South Dakota under the Missouri Basin Program. Studies of the ground-water resources of Montana, in general, have been less numerous, less intensive, and of smaller scope than those in other parts of the Basin. Some ground-water studies in the Basin have been made on a small scale by Federal agencies other than the Geological Survey.

Thus, when the Missouri Basin ground-water studies were started in the fall of 1945 it was found that, although considerable data were available for Nebraska and Kansas and a lesser amount for some other local areas, the lack of even basic ground-water data in most other parts of the Basin was a serious handicap in planning for the maximum utilization of ground-water resources. In most cases not enough information was available for adequate and economical planning of the ground-water phase of future surface-water irrigation projects or for adequate understanding of the ground-water problems (such as high water tables and water-logged lands) on existing projects. Consequently it became apparent that an orderly study of ground water must be made an integral part of the program of the Interior Department for the development of the Basin and that the study should consist of four principal, somewhat overlapping steps: (1) reconnaissance studies to determine apparent needs or potentialities, based on a minimum of field work (this step can be eliminated when the need for further steps is obvious); (2) general studies to obtain a clear understanding of the ground-water conditions of the area, to ascertain more accurately any apparent needs or potentialities, and to point the way for any more detailed studies; (3) detailed studies to obtain answers to specific problems and to obtain quantitative results; (4) post-development studies to observe changes in the ground-water conditions created by man-made causes (such as development of new irrigation projects) or natural causes (such as droughts) and to suggest remedial measures where excessive rises or falls in the water table or artesian pressure occur or are likely to occur. Most of the ground-water studies that have been started and carried on under the Missouri Basin Program have fallen in step (2) above; some work has recently been done under step (1); and a lesser amount has recently been started under steps (3) and (4). Studies of the occurrence of ground water have been made or are in progress in more than 45 different areas in the Basin (see fig. 1).

Essentially all ground-water studies started under the Missouri Basin Program have been in areas of high priority and in connection with irrigation projects proposed or planned by the Bureau of Reclamation. A few have been in areas where projects are planned or are being operated by the Bureau of Indian Affairs and the Fish and Wildlife Service. Studies in three Indian reservations are being made in an effort to locate adequate water supplies for those Indians who must move from valley lands that are to be inundated, and resettle on residual parts of the reservations.

The status of the ground-water studies begun under the Missouri Basin Program before June 30, 1950, is summarized in the accompanying table. Periodic measurements of the water level in selected observation wells have been made in all areas in which studies have been started; in the absence of accurate information concerning safe yields in the Basin, these water-level data give a good integration of the results of all factors influencing the safe yield and will give prior warning when development approaches the safe-yield limit, or warning of detrimentally high water tables in irrigated areas. Continuation of these measurements through project construction and operation stages is planned, and detailed study of problem areas as they develop is contemplated; installation of additional small-diameter (up to 1 inch) water-level-observation wells is needed in many areas now irrigated or proposed for irrigation.

Since the beginning of the Missouri Basin ground-water studies, approximately 30,000 wells have been inventoried. More than 1,000 observation wells have been installed. Periodic measurements of the water level in these and about 2,300 additional wells are being made to determine the cyclic fluctuations of the water levels. The areal geology as it pertains to ground-water conditions has been mapped for the areas studied. Maps showing the contours of the water table or piezometric surface have been prepared for many areas. A few pumping tests have been made to determine the transmissibility, permeability, and storage coefficient of water-bearing materials. Approximately 1,500 samples of ground water have been collected for chemical analysis. Considerable exploratory test drilling has been done under contract on several projects. As of June 30, 1950, a total of 38 ground-water reports had been prepared on areas within the Basin.

Approximately 8,000 irrigation wells in Nebraska withdraw water from underground reservoirs at an estimated rate of 600,000 or more acre-feet per year and supply water for about 400,000 acres of land. Approximately 6,000 irrigation wells are in operation in the lower Platte River valley in Nebraska, supplying water for about 300,000 acres of highly productive land. In the lower South Platte River valley, from Hardin, Colo., to Paxton, Nebr., approximately 1,200 irrigation wells, which supply ground water for the entire or supplemental irrigation requirements for about 250,000 acres of land, withdrew an estimated 198,000 acre-feet of ground water during the irrigation season of 1949. For comparison, the Angostura dam in southwestern South Dakota, the first dam completed under the Missouri Basin Program, forms a reservoir having a storage capacity of 220,000 acre-feet; Lake McConoughy in Nebraska has a storage capacity of 1,948,000 acre-feet; and the Enders dam nearing completion in Nebraska will form a reservoir having a storage capacity of 74,000 acre-feet. These comparisons show that in parts of the Basin the use of ground water for irrigation purposes alone compares with the use of surface waters, and that full development of the ground-water reservoirs is very important to the full development of the natural resources of the Basin.

W. F. Guyton of the U. S. Geological Survey, after a study of all available information, made an estimate of the use of ground water in the United States during 1945. An abstract from his tables, covering those States lying partly or wholly in the Missouri River Basin, is shown below. Although accurate data are not available, it is a generally recognized fact that the use of ground water for many purposes has increased materially during the period 1945-50:

ESTIMATED USE OF GROUND WATER - 1945

(Millions of gallons per day)

State	Irrigation	Industrial	Municipal	Rural (excluding irrigation)	Total
Colorado	400	25	20	25	470
Iowa	...	150	100	75	325
Kansas	100	100	55	55	310
Minnesota	...	100	50	65	215
Missouri	...	130	40	45	215
Montana	25	15	10	25	75
Nebraska	450	35	85	80	650
North Dakota	...	5	10	25	40
South Dakota	5	15	20	35	75
Wyoming	25	10	10	10	55
Total	1,005	585	400	440	2,430
U. S. Total	10,000	5,000	3,000	2,000	20,000

Transpiration by water-loving vegetation and evaporation from areas of high water table account for a large but unknown amount of ground-water use in the Basin. Casual observations and rough estimates indicate that the evapo-transpirative use of water in the Basin may be of the magnitude of 10,000 million gallons per day. It is obvious that the water thus dissipated could not be wholly salvaged, but the potentialities are sufficient to warrant thorough investigation.

Another, and as yet unstudied, potential and perhaps important use of ground water in the Basin is the production of power with water recovered by the de-watering of aquifers not otherwise used. Casual observations indicate the possible availability of large underground storage for this purpose, especially in the upper reaches of the Missouri River. In this area large ground-water reservoirs are believed to underlie lands that now have a detrimentally high water table. It may be possible, by pumping, to lower the water table under these waterlogged lands and to bring them into production (or better production). The water thus pumped might be used for the irrigation of other lands or, on the other hand, it might be of equal or greater value if it were discharged into the Missouri River during periods of low flow and used for power purposes in the several hydroelectric power plants now in operation. Thus, a large potential development of ground water may be possible through utilization of these ground-water reservoirs for storage purposes, emptying them during the summer, fall, and winter months and allowing them to refill during the spring months of high surface-water flow and rapid infiltration.

The utilization of ground water in the Basin involves not only the recovery of the water for the various uses but also the removal and disposal of excess ground water from certain areas. This excess, whether naturally or artificially caused, often causes the water tables to rise too high and leads to the removal of some of the best lands from beneficial use because of waterlogging and its common companion, the concentration of saline deposits on the land surface. In the natural, undisturbed condition, ground-water levels are in a delicate balance, that balance having been established over many centuries. Any change in the recharge to the ground-water body or in the discharge from that body or any change in numerous other factors is reflected in the level at which the ground-water surface reestablishes itself. For example, even the passage of railway trains is commonly and faithfully recorded by gages placed on nearby artesian wells; distant earthquakes often cause prompt fluctuations of the water surface in wells. Likewise, the application of irrigation water to newly developed lands almost always causes underlying ground-water surfaces to rise; whether or not the rise is detrimental is dependent upon several factors. With few exceptions, however, that rise of the water table has waterlogged and concentrated intolerable salt deposits on the surface of good lands in the irrigation projects developed in the Basin to date. The detrimental results are most difficult to predict, and in many instances the basic trouble has not yet been studied adequately enough to permit applying remedial measures on lands already reduced in or removed from production. Much remains to be done toward solving this highly important problem, and the development and conservation of the Basin's water and land resources will be incomplete until the problem is vigorously attacked and solved. Studies may show that it would be preferable in some places to reclaim land by adequate drainage of waterlogged areas rather than to provide supplemental water for areas now irrigated or water for some parts of new irrigation projects. In other places it probably will be found that the water table under waterlogged lands can be lowered by pumping and the pumped water can be used for irrigating other lands or for other beneficial purposes.

Water cannot be withdrawn from the ground without disturbing the natural balance. The withdrawal of ground water for municipal, industrial, or other use will, without fail, create a local lowering of the water table or of the artesian-pressure (piezometric) surface. As long as the withdrawals from the ground-water reservoir do not exceed the natural or artificial recharge to it, there is no cause for alarm. Water is a resource that is not destroyed; it is only used during one or more parts of the hydrologic cycle. The withdrawal of water from a ground-water reservoir can be compared to the withdrawal from a surface-water reservoir; it may be desirable to lower the water level temporarily to provide water during droughts, then to permit the reservoir to recover during wet periods. The only provision necessary is that the withdrawal is not consistently in excess of the replenishment. On the other hand, if the water annually available to recharge the ground-water reservoir exceeds the natural rate of recharge, it may be desirable to increase the annual withdrawals from the reservoir, thus making available more storage capacity each year to accommodate and store the water available for recharging the reservoir. So far as is known, no ground-water reservoirs within the Missouri River Basin are being pumped greatly in excess of the replenishment; the water levels have receded in a few local areas but the conditions are not serious even there.

Even though considerable progress has been made in the evaluation of the Basin's ground-water resources during the period 1945-50, much remains to be done. The ultimate development of the ground-water resources of the Basin will result, among other things, in new demands for considerable cheap electric power to pump water from the ground-water reservoirs; these potential power requirements cannot yet be even approximated because of insufficient knowledge of the location, extent, and safe yield of the subterranean reservoirs. Many of the studies already begun are inadequate in scope because of inadequate financing and delayed timing. The making of adequate ground-water studies is inherently a relatively slow and expensive procedure, as records of water levels throughout a considerable period of time are essential and as ground-water hydrology is, by its very nature, rather complex. Thus, these studies, like all those pertaining to basic resources, should proceed well in advance of development planning or actual construction - unhappily, in most instances, this could not be accomplished under conditions existing to date.

The development and conservation of the ground-water resources of any area should include not only the gathering and scientific interpretation of basic data but also provide for the legal control and protection of the resources. The need for providing for this factor often is not foreseen, is overlooked, or is postponed until irreparable damage is done. In most of the Missouri Basin States ground-water development has not been sufficiently extensive to raise a popular demand for ground-water control laws within the States. Although the rapid decline of artesian pressure in the Dakota artesian basin of North and South Dakota in early part of the present century caused the State legislatures to require some measure of control over free-flowing artesian wells, it is believed that the sentiment favoring such laws is not likely to be strong as long as ground-water supplies are plentiful. However, it is almost certain that the ground-water resources will become fully developed as population increases in the Basin. It may be that this development will come with great rapidity, thus endangering the entire supply and existing developments and giving rise to serious and costly legal difficulties. Waste of ground water is common in areas of artesian flow, and effective State regulations are necessary to preserve this valuable resource. It will be practically impossible to make the maximum and most economical development of the Basin's ground-water reservoirs without adequate regulatory law based on scientific data, and without an understanding of the occurrence and movement of the ground water and its position in the complex hydrologic cycle. The enactment of laws based on other than thoroughly adequate technical and scientific understanding of the existing and probable future conditions could be ruinous. Thus, even though a need for such regulation is urgent in some instances, it should proceed cautiously and be well founded.

In certain areas the lack of adequate ground-water regulations is already hampering the planning for ground-water developments and those involving balanced ground-water and surface-water use. This is true especially in Nebraska and Colorado and will undoubtedly be true in other Basin states within the not-too-distant future. Surface and ground water are very closely and complexly related; the necessity of regulating the development of ground-water supplies is equally as important and necessary as regulating the development of surface-water supplies. Although in most of the Basin States surface-water law is well advanced, regulations concerning surface water generally are not closely applicable to ground water because of inherent differences in the occurrence and movement of ground and surface water. Also , quantitative studies of the occurrence and movement of ground water are much more complex and difficult than are those of surface water.

Competent engineers, geologists, and attorneys in each Missouri Basin State should pool their knowledge in order that the best possible ground-water regulations can be worked out at the earliest possible date. The regulations should take into account existing laws and existing hydrologic conditions in the respective States; moreover, they should recognize the interstate character of streams and ground-water reservoirs and the interrelationship of ground and surface water. The opportunity for collecting, in the process of the operation of the regulations, additional valuable ground-water data should not be overlooked. As each State's ground-water knowledge becomes greater, those regulations should be periodically reviewed and revised to conform to the new knowledge and problems.

The Interior Department's program in the Basin has given added impetus to the study of the ground-water resources, although to date our knowledge has not reached even the minimum level or continuity required to protect the Federal Government's or the States' existing developments, and the program has made little progress toward the discovery and development of undoubtedly existent but as yet unknown ground-water reservoirs. A great percentage of the available ground-water knowledge of the Basin is general rather than quantitative. To develop this resource fully and economically, quantitative knowledge must be obtained.

Although the quantity of ground water that can be recovered safely in the Basin year after year cannot yet be determined even approximately, it is known that the amount of ground water stored in hidden underground reservoirs exceeds by many times that likely ever to be stored in surface reservoirs. A comprehensive knowledge of the location and safe yield of the Basin's ground-water reservoirs would assist materially in more efficient planning for maximum use of all water resources and undoubtedly would influence to a great extent much of the present and future planning and perhaps cause in some instances a considerable revision of present evaluations of the water resources of the Basin. The availability of the Basin's ground-water supplies for national-defense purposes cannot be evaluated in terms of money; of the many defense plants and installations that have been and may be located in the Basin, few could be so located were it not for the existence of acceptable ground-water supplies.

The economy of the Basin and, in turn, its value to the Nation have been and are based to a great degree on the availability of acceptable ground-water supplies. Much of the future development of the resources of the Basin - agriculturally, industrially, and otherwise - will be governed or greatly influenced by the availability of ground-water supplies of usable quality. Although other natural resources may be readily available, the extent to which they may be utilized is often dependent in large part on the quantity and quality of the ground water that is available at economical cost. The development of the water resources of the Basin necessarily affects existing ground-water conditions, and the magnitude of these effects likewise may be a limiting factor in the Basin's development. Yet, considering the relative quantity, extent, and importance of the ground-water supplies, there are few other resources of the Basin upon which smaller expenditures have been made to understand, develop, and conserve them and about which fewer data are available.

Summary of ground-water studies under the Missouri Basin Program
(1945-50, incl.)

A, released for administrative use.
C, completed.
G, printed as Geological Survey circular.
K, printed as Kansas Geol. Survey bull.
O, released to open file.
P, in progress or in preparation.

Area or subarea	Reconnaissance		General			Detailed		
	Field studies	Report	Field studies	Progress report	Final report	Field studies	Progress report	Final report
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ABOVE FORT PECK								
1. Lower Marias	-	-	C	A	P	-	-	-
2. Helena Valley	-	-	C	-	A	a	-	-
3. Crow Creek-Townsend	-	-	P	P	-	-	-	-
YELLOWSTONE RIVER BASIN								
4. Yellowstone River Valley (Sidney to Glendive)	-	-	C	-	P	-	-	-
5. Yellowstone River Valley (Glendive to Miles City)	-	-	C	-	P	b	-	-
6. Yellowstone River Valley (Miles City to Forsyth)	-	-	c	-	-	-	-	-
7. Shoshone project (Heart Mountain and Chapman Bench)	-	-	C	-	A	-	-	-
8. Paintrock project	-	-	C	-	A	-	-	-
9. Owl Creek project	-	-	C	-	A	-	-	-
10. Riverton project (Area between Wind River and Cottonwood Creek)	-	-	P	A	-	-	-	-
11. Kaycee area	d	-	-	-	-	-	-	-
MISSOURI RIVER SUBDIVISION-FORT PECK TO SIOUX CITY								
12. Missouri River Valley (Fort Peck to North Dakota state line)	-	-	C	-	P	-	-	-
N-Bar-N Unit	-	-	-	-	-	C	P	-
Chelsea Bench Unit	-	-	-	-	-	C	P	-
13. Medicine Lake-Grenora area	-	-	C	O	-	-	-	-
14. Missouri-Souris area (N. Dak.)	-	-	P	O	-	-	-	-
Bowbells Block area	-	-	-	-	-	P	P	-
15. Fort Berthold Indian Reservation	-	-	P	P	-	e	-	-
16. Missouri River Valley (Garrison Dam to Bismarck)	-	-	f	-	-	-	-	-
17. James River Valley (N. Dak.)	-	-	g	-	-	-	-	-
18. Cheyenne and Standing Rock Indian Reservations	-	-	P	P	-	-	-	-

Summary of ground-water studies under the Missouri Basin Program (1945-50, incl.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
19. James River Valley (S. Dakota)	-	-	P	O	-	P	P	-
MINOR WESTERN TRIBUTARIES								
20. Knife River Valley	-	-	h	-	-	-	-	-
21. Heart River Valley	-	-	C	-	G	-	-	-
22. Grand River Valley	-	-	C	A	P	-	-	-
23. Rapid Valley project	-	-	C	P	-	-	-	-
24. Belle Fourche project	-	-	i	-	-	-	-	-
25. Angostura project	-	-	C	-	G	-	-	-
26. Niobrara River Valley	-	-	jP	P	-	-	-	-
PLATTE RIVER DIVISION								
27. La Prele area near Douglas	P	-	-	-	-	-	-	-
28. Glendo area	C	P	-	-	-	-	-	-
29. Wheatland Flats area	C	A	-	-	-	-	-	-
30. Laramie Plains area	C	A	-	-	-	-	-	-
31. Horse and Bear Creeks area	C	P	-	-	-	-	-	-
32. North Platte Project (Barthel area, Goshen Hole)	-	-	-	-	-	P	P	-
33. North Platte Project (Dutch Flats area)	-	-	P	P	-	-	-	-
34. Pumpkin Creek Valley	C	P	-	-	-	-	-	-
35. South Platte River Valley (Hardin, Colo., to Paxton, Nebr.)	-	-	P	O	P	-	-	-
36. Box Butte County, Nebr.	-	-	C	O	P	-	-	-
37. Nebraska Sand Hills area	k	-	-	-	-	-	-	-
38. Lower Platte River Valley (North Platte to Fremont)	-	-	P	G	-	-	-	-
Wood River Unit	-	-	C	P	-	-	-	-
Prairie Creek Unit	-	-	P	-	-	-	-	-
39. Platte-Republican Divide area	-	-	mC	-	-	-	-	-
40. Loup River Basin (Middle Loup Unit)	-	-	P	-	-	-	-	-
KANSAS RIVER BASIN								
41. Republican River Valley	-	-	P	G	-	-	-	-
Bostwick Unit	-	-	-	-	-	P	-	-
Upper Republican River Valley	-	-	-	-	-	P	-	-
42. Almena Unit	-	-	C	-	K	-	-	-
43. Solomon River Valley								
Kirwin Unit	-	-	C	-	P	-	-	-
Webster Unit	-	-	h	-	-	-	-	-
Glen Elder Unit	-	-	h	-	-	-	-	-
44. Saline River Valley (Wilson Unit)	-	-	C	-	P	-	-	-
45. Smoky Hill River Valley								
Cedar Bluff Unit	-	-	C	-	P	-	-	-
Kanopolis Unit	-	-	C	-	K	d	-	-

Footnotes:

a. Need for detailed work dependent on results of recommended economic and other studies.

b. To be started during 1950 field season in Buffalo Rapids Project No. 1.

Footnotes - Continued

c. General study started but deferred for higher priority items.

d. To be started during 1950 field season.

e. Exploratory drilling to locate acceptable domestic supplies for displaced Indians scheduled for 1950 field season.

f. To be started during 1951 fiscal year.

g. Periodic water-level measurements being made in New Rockford, Jamestown, and Oakes Units.

h. Periodic water-level measurements being made.

i. Periodic water-level measurements being made; general studies scheduled for 1950 field season.

j. In Valentine Wildlife Refuge area; periodic water-level measurements being made in Ainsworth and O'Neill areas.

k. Started but postponed pending availability of topographic maps and increase in priority.

m. completed for part of area; continuation of study deferred in favor of higher-priority items.

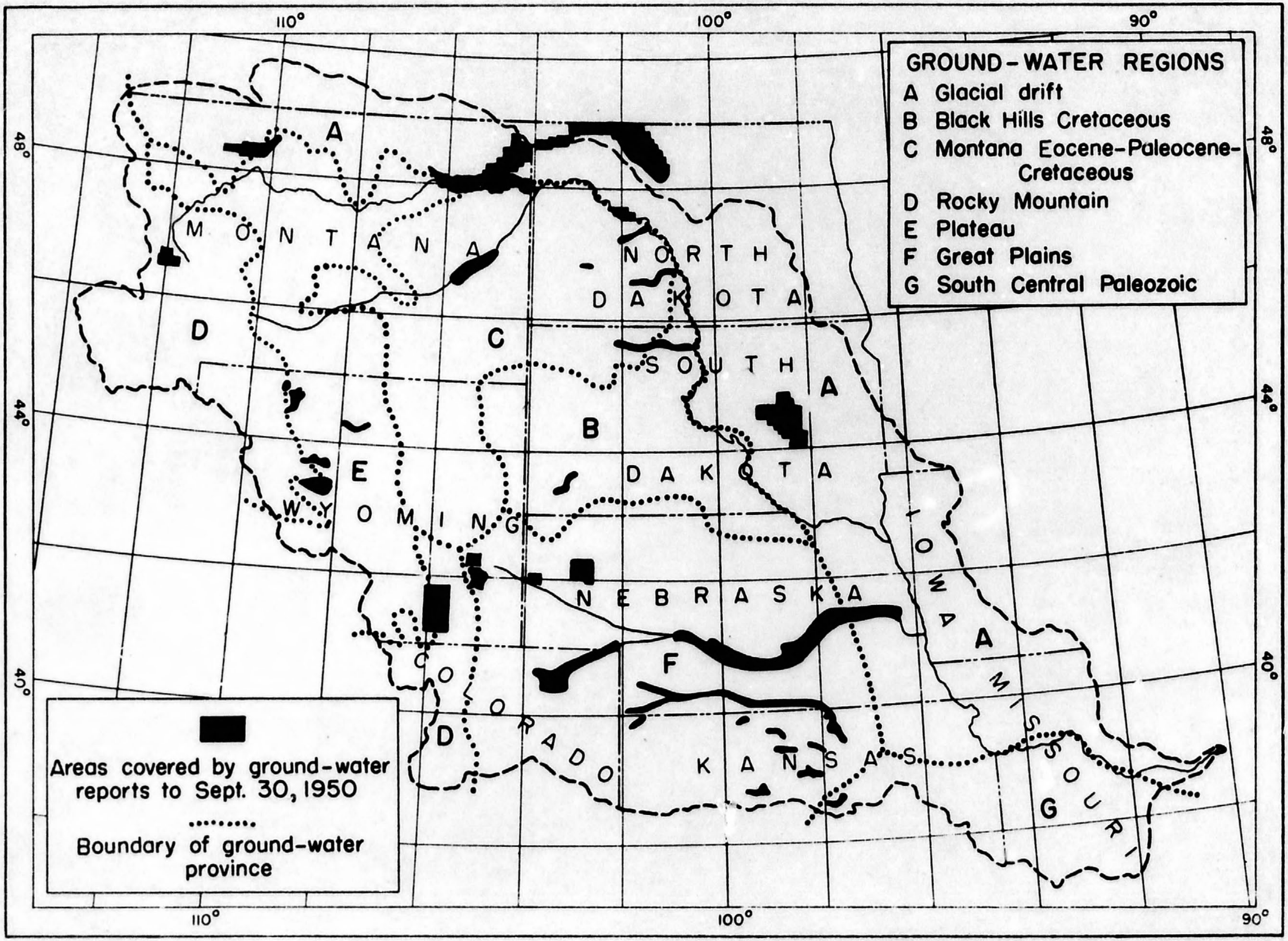

Figure 1.—Map of the Missouri River Basin showing areas in which ground-water reports have been made under Missouri Basin program and ground-water regions