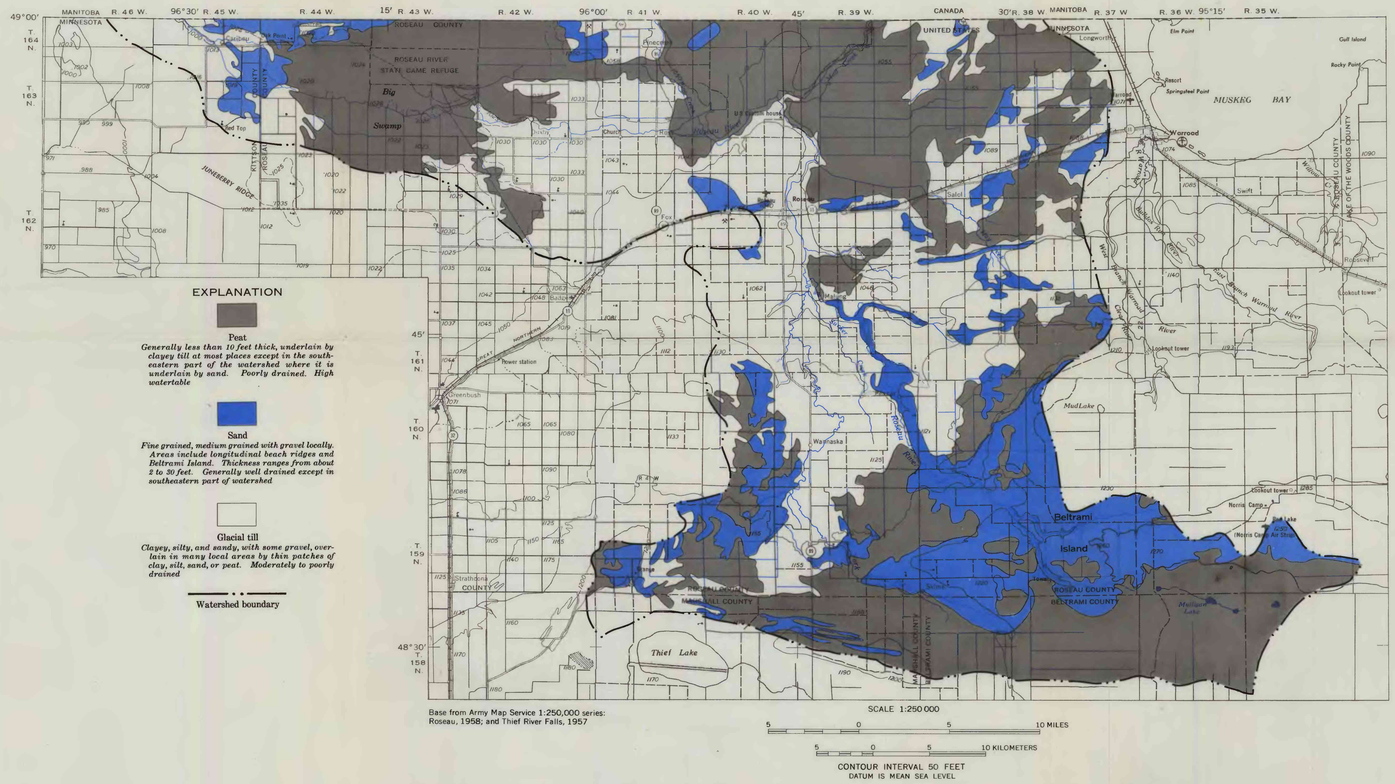
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH
THE MINNESOTA DEPARTMENT OF CONSERVATION
DIVISION OF WATERS

HYDROLOGIC INVESTIGATIONS
ATLAS HA-241 (SHEET 1 OF 3)

PHYSICAL SETTING AND WATER MANAGEMENT



EXPLANATION

Peat
Generally less than 10 feet thick, underlain by clayey till at most places except in the southeastern part of the watershed where it is underlain by sand. Poorly drained. High watertable

Sand
Fine grained, medium grained with gravel locally. Areas include longitudinal beach ridges and Beltrami Island. Thickness ranges from about 2 to 30 feet. Generally well drained except in southeastern part of watershed

Glacial till
Clayey, silty, and sandy, with some gravel, overlain in many local areas by thin patches of clay, silt, sand, or peat. Moderately to poorly drained

Watershed boundary

Base from Army Map Service 1:250,000 series: Roseau, 1958; and Thief River Falls, 1957

SCALE 1:250 000
5 0 5 10 MILES
5 0 5 10 KILOMETERS
CONTOUR INTERVAL 50 FEET
DATUM IS MEAN SEA LEVEL

THE DRAINAGE AREA OF THE ROSEAU RIVER CONSISTS OF 2,060 SQUARE MILES ABOVE ITS CONFLUENCE WITH THE RED RIVER OF THE NORTH
About 1,150 square miles lie in the United States and 910 square miles in Canada. This report deals only with that portion within the United States, except for a detailed analysis of low flow characteristics of tributary streams

Most of the area is within Roseau County, but small portions are in Marshall, Beltrami, Lake of the Woods, and Kittson Counties. Most of the watershed has little relief, and lies entirely within the plain of former Glacial Lake Agassiz. However, the flat topography of this lake washed till plain is broken by beach ridges in its southwestern part and Beltrami Island, a topographic high underlain by sand, in its southeastern part

Population within the watershed is about 8000. The town of Roseau, the largest community, has a population of 2146 (1960)

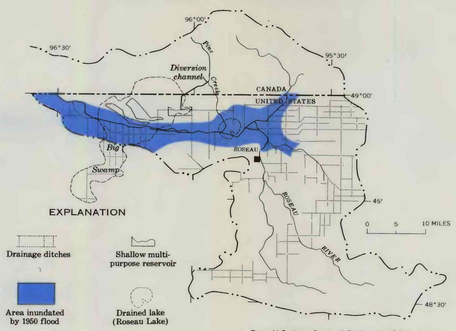
The watershed has an agricultural economy. Spring wheat, oats, and bluegrass seed are the three most important crops in the area, but many other small grains, legumes, and grasses are also grown. Dairy farming and sheep raising are the most important types of livestock production and for many farms stock is the major source of income

Large areas of the watershed are peat lands, covered with shrubs, marsh grasslands, and spruce, tamarack, and cedar trees. Forest vegetation in the remainder of the area is largely aspen, but oak is common on the beach ridges and jack pine is common on Beltrami Island

Outdoor recreation in the area is primarily hunting of deer, small game, and waterfowl

This report is a general appraisal of the water resources in the Roseau River watershed unit. Detailed studies of water movement through the ground-water reservoir are needed for more exact determination of the amount of water immediately available and the specific effects of water-management practices

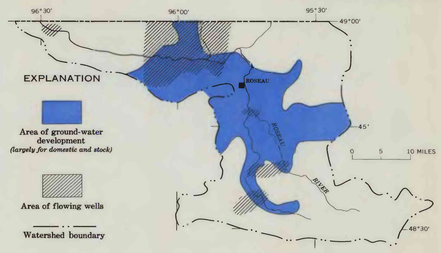
SURFACE-WATER MANAGEMENT



EXPLANATION
Drainage ditches
Shallow multi-purpose reservoir
Area inundated by 1950 flood
Drained lake (Roseau Lake)
Watershed boundary

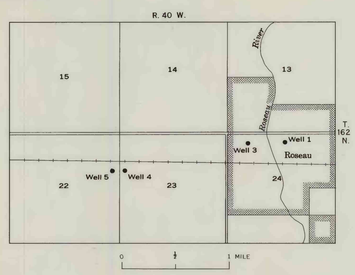
From U.S. Army Corps of Engineers, 1964, report on survey of Roseau River, Minnesota for flood control

GROUND-WATER MANAGEMENT



EXPLANATION
Area of ground-water development *(largely for domestic and stock)*
Area of flowing wells
Watershed boundary

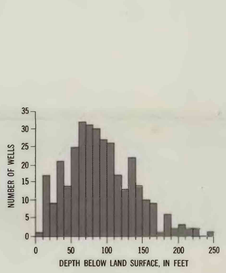
MOST GROUND-WATER PUMPAGE IS WITHIN A 470 SQUARE MILE AREA
Few wells have been constructed in the remainder of the watershed, which is largely non-agricultural



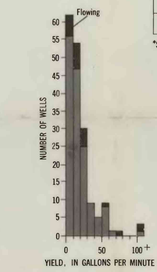
Town well number	Depth (feet)	Diameter (inches)	Yield (oper. rate) (gpm)	Yield (tested) (gpm)	Water level (static) ft below Ls	Water level (pumping) ft below Ls	Date drilled
*1	112	8	240	—	18	88	1934
**3	118	12	35	35	—	—	1938
4	147	8	200	280	8	78	1945
5	155	10	390	—	20	55	1961

*Standby well **U.S.G.S. observation well

MUNICIPAL WELLS IN ROSEAU ARE ADEQUATE FOR PRESENT NEEDS



MOST WELLS ARE BETWEEN 50 AND 150 FEET DEEP



WELL YIELDS ARE GENERALLY LESS THAN 20 GALLONS PER MINUTE (mostly domestic and stock wells)

WATER USE
(in million gallons per year)

Ground water	Municipal (Roseau)		
	Industrial & Commercial	41.2	1963 data
	Domestic	27.5	
	Rural		
	Domestic	45.5	1960 data
	Stock	103.1	1954 data
Surface water	Surface water is not used for municipal purposes in the watershed and only a very small amount is used for watering stock		

GROUND-WATER DEVELOPMENT

Well construction

More than 90 percent of the wells are drilled. Most are 4 inches or less in diameter. About 50 percent of the wells are screened

Well maintenance and operation

Because ground water in the watershed contains much calcium, magnesium, and bicarbonate ions in solution, well screens become encrusted, which results in a decline in well yield. The useful life of the screen depends upon well efficiency, the pumping rate, and the chemical quality of water. Some screens reportedly are replaced each 2 years, but most screens are used for 5 to 10 years.

Many of the older wells, some of which are more than 50 years old and many of which are not screened, flow continuously at a restricted rate. Well owners report that well life is longer for those wells that are allowed to flow than wells that are shut off

Some wells with natural flow are pumped to increase their yield. Several wells of this type yield more than 100 gallons per minute. Natural flows range from less than 1 gpm to more than 50 gpm, but most flows are less than 10 gpm

Effect of pumpage on ground-water reservoir

Natural conditions before development

The ground-water reservoir is nearly full. In the area of rural pumpage the water level generally is within 10 feet or less of land surface. Water levels fluctuate seasonally as much as 5 to 10 feet in some wells due to variations in recharge from precipitation. A natural balance exists between recharge from precipitation and ground-water discharge to streams and swamps

Water level decline with development

No widespread decline in water levels has occurred in the watershed. Locally water levels have declined near wells and have stabilized with existing pumping conditions. Most of the water pumped is being diverted from evapotranspiration losses

Problems	Natural conditions affecting water management	Management plans or operating solution
Flood alleviation along Roseau River— Spring flooding along the Roseau River between the village of Roseau and the Canadian border is the major water problem in the watershed. The area inundated by the 1950 flood, the maximum recorded flood, is shown on map above. It covered 85,000 acres of which 75 percent is agricultural lands. Total loss from this flood was evaluated by the U.S. Army Corps of Engineers (1964) to be more than $1,000,000. Average annual flood damage is estimated to be $483,000 or about $12.97 per acre for agricultural lands (U.S. Army Corps of Engineers, 1964)	Average annual snowfall is about 34 inches; the maximum recorded in the region was 77 inches at Warroad, Minn. in 1935. Continuous low winter temperatures prevent snowmelt prior to the spring breakup, resulting in spring floods. Summer thunderstorms account for about 50 percent of the annual precipitation. Intense thunderstorms result in flooding Low channel gradient, low bank, and adjacent flat terrain contribute to extensive flooding downstream from village of Roseau. Flood peaks are of long duration because of large natural storage. Steeper channel gradient and higher banks upstream from the village of Roseau result in less flooded area and flood peaks of short duration Roseau Lake acts as a natural retarding basin during periods of high flow, decreases peak flows, and extends the period of high runoff downstream. The reach of Roseau River in Big Swamp has a low channel capacity of about 700 cubic feet per second at a bankfull stage of 7 feet. Above this stage, water moves southward from the Roseau River and escapes the watershed along drainage ditches shown on map. Channel gradient in Big Swamp of 0.2 foot per mile is a minimum for the river	A. Plans for flood-alleviation measures using storage: Much of the channel between Roseau Lake and the international boundary was dredged and straightened between 1906 and 1920, resulting in draining Roseau Lake B. Two major plans for flood control utilizing storage are presently proposed by the Corps of Engineers: 1. Utilization of Roseau Lake, as a reservoir for retarding flood runoff because of the hydrologically favorable location near the confluence of the tributaries that contribute most of the flood flows. This plan would result in loss of excellent soils for cultivation within the reservoir site. Also, the capacity of the reservoir is small 2. Extensive shallow reservoirs impounded behind low levees in Big Swamp. This plan would not result in a loss of cultivated lands and would establish an excellent pool for wildlife C. Plans for flood alleviation without storage: A plan in operation calls for channel improvement of the main stream of the Roseau River below Hay Creek supplemented by a local program of tributary ditch construction in Minnesota and limited channel improvement in Canada. The channel improvement above Big Swamp would provide channel capacity for all flows up to those having an expected frequency of occurrence of once in 10 years. The channel capacity is designed to decrease excessive flows across the border
Land drainage— Losses due to crop damage, late planting, and poor land utilization have resulted from slow farm drainage and inadequate drainage outlets An extensive but not fully adequate system of drainage ditches has been constructed since the early part of the century. Drainage of large swamp areas, included in the early program, proved unsuccessful because the land could not be farmed profitably. Much of this land has been returned to the State after assumption of obligation for ditch bonds. Land acquired by the State has been designated for game preserves, reforestation, flood control, or has been leased or resold Drainage of better agricultural lands was economically successful; however, the ditch system is inadequate during years of above normal precipitation or periods of intense rainfall Effectiveness of many ditches is reduced by small capacity due to shallow depth, overgrowth, and inadequate outlets	A large part of the watershed was poorly drained under natural conditions. Swamps are difficult to drain because peat deposits yield water slowly and hydrologic gradients are low	A. In Roseau County about 680,000 acres of land are drained by 927 miles of ditch (U.S. Army Corps of Engineers, 1964, p. 9). Annual cost for repair and maintenance is about $200,000 B. Provisions for increasing the capacity of outlet ditches to the Roseau River and its tributaries and increasing the capacity of the natural streams are planned before the construction of additional farm ditches. Drainage plans include provisions for ditch maintenance
Conservation and recreation— Habitat for game propagation is confined to swamps and small areas adjacent to ditches. Areas for hunting migratory waterfowl are small. Since 1900 drainage for agricultural purposes has greatly reduced the natural habitat of wildlife which resulted in significant reduction in population of small game	Flat, swampy, brushy areas provide excellent potential sites for extensive shallow pools or reservoirs behind low dams. Pine Creek provides a good source of surface water for maintaining pool levels	Facilities for Roseau River Game Refuge and public hunting grounds were constructed during the early 1950's. These works included a diversion channel and control provisions on Pine Creek in Canada, and three pool areas in Minnesota. The control works are capable of diverting 450 cubic feet per second to the Refuge and include provision for a continuous low flow through the existing channel. The diverted flow enters each successive pool by discharging over spillways before entering Roseau River
Pollution— Pollution has not been a major water problem in the watershed	Streams have low capacity for diluting and transporting waste during periods of ordinary and low flows	Village of Roseau, the only municipality, has a sanitary sewer system and a waste-treatment plant. Industrial waste from Roseau is treated in the sewage plant. Treated waste is discharged to the Roseau River

A C K N O W L E D G E M E N T S

We express our appreciation to the well owners and well drillers in the area for their excellent cooperation in providing basic data for this study. We thank the O. K. Machine Co., Roseau, Minn., in particular, who furnished us with numerous records of wells in the area.

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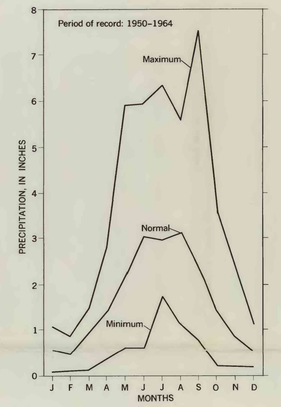
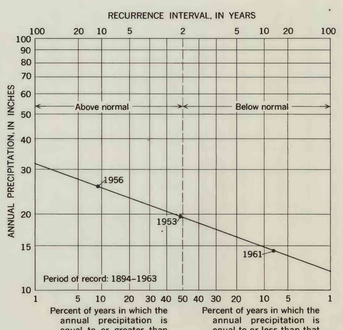
WATER BUDGET AND SUMMARY



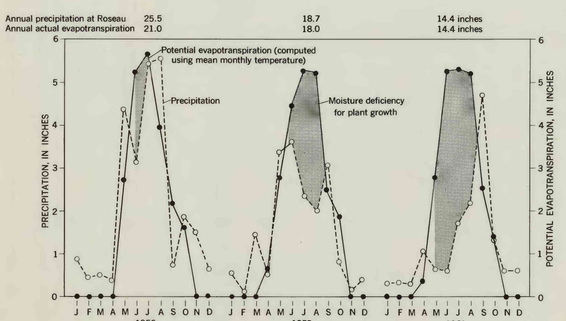
CLIMATIC SUMMARY
Modified from Minnesota Division of Waters, Bulletin 10 (1959)

Station			Roseau Power Plant
Years of record			53
Temperature °F		Maximum	107
		Mean annual	37.5
		Minimum	−52
Precipitation in inches	Annual	Maximum (year)	25.97 (1925)
		Mean	19.26
		Minimum (year)	12.03 (1933)
		Snowfall (mean—unmelted)	34.1
	Mean	April-September	14.71
		October-March	4.55
	Maximum 24 hours		5.07 (9-2-57)

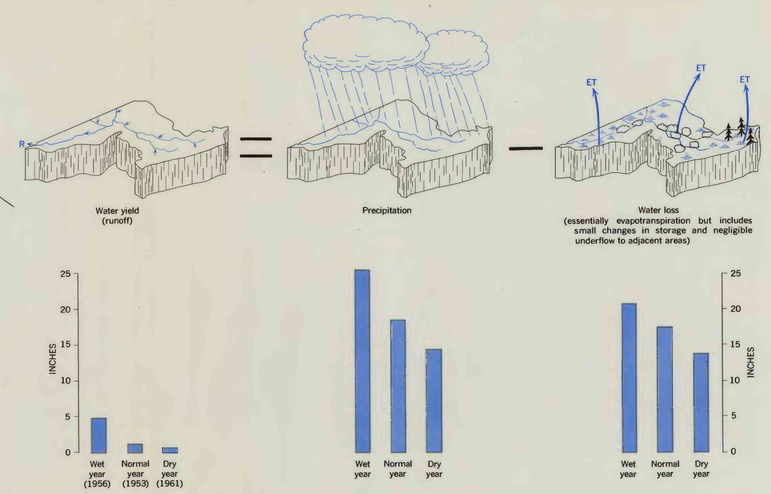
THE ROSEAU RIVER WATERSHED HAS A CONTINENTAL CLIMATE CHARACTERIZED BY WIDE VARIATION IN TEMPERATURE, SCANTY WINTER PRECIPITATION, AND NORMALLY SUFFICIENT SUMMER RAINFALL
Average precipitation during the period from April through September is about 15 inches. Thunderstorms are the principal source of precipitation during this period. Average annual snowfall in the watershed is about 34 inches. Crop failures due to drought can be expected on the average once every 10 years (U.S. Dept. of Commerce, Weather Bureau, 1959)



FREQUENCY DISTRIBUTION CURVE OF ANNUAL PRECIPITATION AT ROSEAU MINNESOTA SHOWS RECURRENCE INTERVALS OF THE YEARS SELECTED TO ESTIMATE WATER YIELD FOR ABOVE NORMAL (1956), NEAR NORMAL (1953), AND BELOW NORMAL (1961), PRECIPITATION
Years selected were dependent upon available surface-water records



ANNUAL ACTUAL EVAPOTRANSPIRATION AT ROSEAU MAY APPROXIMATELY EQUAL ANNUAL PRECIPITATION EVEN DURING YEARS OF NORMAL PRECIPITATION
Annual actual evapotranspiration was calculated by the method developed by Thornthwaite and Mather (1957) which is based on the monthly precipitation, the mean temperature for the month, and an average capacity for moisture storage in soils. Moisture storage in the watershed is estimated to be 8 inches



WATER YIELD OF THE WATERSHED IS LOW
Ground-water flow into and out of the basin is considered small and natural water losses, largely through evapotranspiration, are high. Total water yield depends upon storing runoff in either ground or surface reservoirs. The yield of the watershed is 294,000 acre-feet for 1956, 74,000 acre-feet for 1953, and 43,000 acre-feet for 1961

SUMMARY OF WATER RESOURCES

Purpose	Considerations	Surface water: Roseau River below Roseau	Surface water: Roseau River above Roseau	Surface water: Tributaries	Ground water: Surficial sand	Ground water: Sand within till
Municipal and industrial supply	For a moderate supply, principal needs are: 1) About 1cfs or 450 gpm 2) Total dissolved-solids content less than 500 ppm 3) Iron content less than 0.3 ppm 4) Hardness less than 180 ppm	Discharge of Roseau River at Ross is seldom less than 5 cfs Total dissolved solids ranges from 179 to 328 ppm Lack of natural storage sites	Natural storage sites are available. Water quality is adequate Without storage, low flows are inadequate.	Pine Creek has adequate base flow but is being used for wildlife refuge Other tributaries generally have inadequate base flow.	Large areal extent Easy construction of wells Beltrami Island area is largely State owned forest lands Yields of individual wells generally less than 100 gpm Low available head for drawdown	Large amounts of water in storage High available head for drawdown Test drilling required to locate most productive zones within the aquifers Iron content and hardness may exceed limits indicated
Rural domestic and stock supply (largely dairying)	For an adequate farm supply, needs are: 1) About 5 gpm or more 2) Total dissolved-solids content less than 1,000 ppm.	Available only to riparian lands.	Available only to riparian lands.	Available only to riparian lands	Large areal extent Easy construction of wells Yields are adequate Suitable quality Easily contaminated	Yields are adequate Wells can be completed at most places Because of low temperature, water is suitable for cooling Iron content may be too high for dairy use.
Wildlife habitat	For good wildlife habitat, the basic need is adequate cover provided by: 1) Wetlands...swamps 2) Natural water courses and ditches	Flows through Big Swamp, which is partially used for wildlife refuge Drainage for agricultural purposes tends to decrease wetlands.	Roseau River flows through extensive swamp in headwaters area	Many secondary ditches are overgrown and provide cover All tributaries have extensive adjacent swamplands.	EXPLANATION Advantages Large areal extent Easy construction of wells Yields are adequate Suitable quality Disadvantages Easily contaminated Overall evaluation for purpose and considerations indicated Good Fair Poor	
Irrigation supply	Generally not practiced in watershed because of inadequate drainage					

C O N C L U S I O N S

1. An extensive system of drainage ditches for reclamation of swamplands was constructed mostly during the period from 1900 to 1920. Drainage of swamplands has not been effective and most of these ditches are no longer maintained
2. Ground-water development is confined largely to a 470 square mile area in the central part of the watershed. The development is not intense and no significant widespread decline in water levels has occurred
3. Water yield in the watershed is low, about 1 inch during a year of normal precipitation. The total estimated yield in the Minnesota part of the basin ranges from about 294,000 acre-feet for wet years to about 43,000 acre-feet for dry years
4. Floods due to meltwater runoff in the spring and storm runoff after intense thunderstorms during the summer results in estimated average annual flood damage of $483,000(as reported by the U.S. Army Corps of Engineers, 1964). These floods occur in the lowlands along the Roseau River and its tributaries
5. Low flows of streams draining sandy areas are considerably greater than those draining swamp and till areas. Runoff from swamps does not contribute significantly to stream discharge during periods of low flow
6. A high water table throughout the watershed indicates that the ground-water reservoir is essentially full
7. Recharge of the ground-water reservoir occurs in the higher sandy areas. Discharge is usually to nearby lowland areas or to the streams within the recharge area
8. Moderate supplies of ground water for domestic and small industrial and community supplies are available at most places in the watershed
9. Surface-water quality is uniform despite wide range in discharge.
10. Ground water is very hard, is high in iron content, and ranges widely in total dissolved-solids content

WATER RESOURCES OF THE ROSEAU RIVER WATERSHED, NORTHWESTERN MINNESOTA

By
T. C. Winter, R. W. Maclay, and G. M. Pike

1967

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